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Forthcoming Events.

FEBRUARY 11.

British Foundrymen's Association (Scottish Branch).—"Some Causes Inducing to Fracture in Metals," by Prof. A. Campion (West of Scotland College, Glasgow).

FEBRUARY 21.

British Foundrymen's Association (Sheffield Branch).—"Some Methods of Testing Materials of Construction," by W. Cleland, B.Sc.

FEBRUARY 25.

British Foundrymen's Association (Birmingham Branch).—"The Manufacture of Foundry Coke, Past and Present," by G. W. B. Stephen.

NOTES AND COMMENTS.

Improved Cast Iron.

The lecture delivered under the above title by Mr. J. F. P. Lewis to the Scottish Branch of the British Foundryman's Association, a full abstract of which appears on another page, contains a good deal of matter of genuine interest to the ironfounder, and possibly a good deal calculated to engender controversy amongst experts. The strong line taken up by the lecturer against the use of steel in the iron foundry cupola may be criticised in some quarters, but it is one with which we ourselves are inclined to sympathise until the evidence of real gain through steel additions is both more general and more specific.

The lecturer is a member of the technical staff of the Frodair Iron and Steel Company, and would be perhaps unfaithful to the interests of his Company, who are dealers in special pig-iron, if he took up publicly the other view; but the lecture is quite free throughout both in matter and style from any taint of axe-grinding, and it may be credited to Mr. Lewis that his remarks are an unbiassed expression of his own real views based on wide experience of general foundry practice. In any case the table of tests on different mixtures of iron put forward (along with the test pieces) at the lecture, go to show that results very much surpassing the ordinary, as regards both mechanical and physical qualities, can be achieved with mixtures of pig-irons of first smelting alone, as witness tensile records as high as 18.39 tons, transverse (standard bar) 1.9 tons, deflection 0.468 in. and specific weight 7.3. These are figures which any founder seeking assistance from steel may be well satisfied to equal; and, further, he will have to show that such results can be readily and regularly produced by the steel addition method as a commercial process in any foundry, since the lecturer made it clear that he was not addressing himself to the specially skilled nor to the exceptionally equipped, but to the average ironfounder. As regards the question of mixing irons to get a desired result in the casting, the lecturer's view seems to be that neither a system of working by analysis alone nor an empirical system alone is sufficient to ensure success, but an intelligent combination of both, where the exactly correct balance and compromise is found between the observances based on the pre-established rules of the chemist as applied to cold cast iron and those based on the practical experience of the founder in melting and moulding.

It cannot certainly be too constantly borne in mind that on the one hand the purity of an iron casting, say, as regards the absence of phosphorus and sulphur, may be purchased at too great a cost of general working qualities in the metal in the foundry, and that, on the other hand, these good working qualities may be secured at the cost of far too great a loss of strength, density and durability in the casting. The main trend of the lecture must meet with general approval. It is really a plea for better iron and better castings, and we certainly think there is plenty of scope for improvement of quality and ex-

tension of trade in many of the types of engineers' castings mentioned. In most cases where iron castings which have failed under the working test are analysed and examined, it is found that they are very far removed from what they should and could have been, either in chemical composition, structure, or design or possibly in all of these. Wherever in such a case cast iron has been abandoned by an engineer for the work it had been doing in favour of another material, an injury has been done to the ironfounding industry; for it must be remembered that the engineer is not then rejecting cast iron because he believes that it is not adaptable to his purpose, but because he feels that the ironfounder cannot be trusted to serve him truly and well. We hold no particular brief for ironfounding as opposed to steel founding, but we do desire—and it should be the desire of every honest man—that each branch of the foundry industry should do the best it is capable of.

The Output of the Jobbing Foundry.

It has often been a matter of surprise to many advanced foundrymen, particularly those associated with modern, well-equipped works, and who appreciate the difficulty of getting satisfactory castings even under favourable conditions, that the host of small foundries all over the country which run on one cupola only should be able to turn out their great variety of work with any maintained degree of success. It seems almost paradoxical, in face of the fact that even in foundries well equipped and utilising the aid of science, "wasters" and faulty castings are by no means uncommon, that small jobbing foundries working only one cupola and practically one mixture continue to meet the demands placed on them; for though "wasters" are no strangers in such foundries, the variety of work turned out there is very considerable, ranging from such simple items as sash weights to complicated machinery parts in which strength and soundness are essential features. How do these small concerns keep up their standard and satisfy this varied demand, despite the features which place them at such a disadvantage as compared with larger and better equipped plants? For it must be admitted that they do meet it, at least to a considerable extent. In larger works a special cupola will be devoted to melting for a particular class of work, and special mixtures will be employed, graded to suit the requirements of the casting. But the jobbing man runs his one cupola and pours his cast at the end of the day from the one mixture, despite the fact that the jobs on the floor cover a very wide range of classes. This fact should go a long way to support the claim that the practical experience and skill of the "rule-of-thumb" man is not to be despised. It must be evident that there are other matters of weight in the production of good castings than the selection of suitable metal, or the No. 3 pig and scrap mixture so largely used would not give the all-round good results which it does. Of course, a good deal is undoubtedly done by selecting the moulds to be poured from the various lots of metal that come down. For instance, the foundryman would not usually pour those important castings which have to meet strength requirements, and which probably have to be machined, from the first batch of metal. That metal goes to a less important class of castings where hardness is no drawback, and as the condition of the metal changes as the result of blast or other variations, so would it be applied to one or another purpose. But apart from this there are many successes secured as the result of good moulding, in the arrangement of the gates, runners, sinking heads, and risers, and the individual skill of the man with the feeding rod—points which are often simply the result of experience with a great variety of work and the associated difficulties. The discrete baring of heavy parts during cooling; the judicious use of chills; care in feeding heavy parts; and the proper use of sinking heads to obtain increased density in the mould—these are a few of the aids to the man who cannot call on special mixtures and the services of the chemist to give him the density and strength he requires. The great variations in the results that can be obtained by variations in the cooling conditions of metal from the same ladle explain to some extent, the scope before the resourceful foundryman; and where science holds a powerful sway as regards the cupola and its contents, the matter of cooling often receives less than its proper attention.

The Use of Chills.

The question of cooling has been dealt with fairly fully at times in technical foundry circles, and such researches as the well known experiments of Mr. F. J. Cook have done a great deal to explain the phenomena. A good deal of misunderstanding, however, appears to exist in some quarters as to the actual effect of chills when applied to heavy parts to prevent the formation of shrinkage or draw holes. As is fairly well known, shrinkage cavities or draw holes result from one part of the casting cooling more rapidly than an adjoining part, owing to difference in thickness, and drawing from the latter to feed the shrinkage that takes place during cooling. When the thick part in question is cast in contact with a chill, however, that accelerates the cooling and assists in preventing the spungy structure which results from the drawing to feed the thin part, producing instead a close, compact gain. But while the surface may present this clean, dense surface, it must not be supposed that the same necessarily applies to the centre of that part of the casting. The depth to which this close structure is carried will, of course, depend largely on the thickness of the chill in relation to the weight of metal against it, but, as a rule, on breaking up such a casting it will be found that the draw hole has not been prevented, it still being in the centre of the thick part. The actual effect of chills is generally to consolidate the structure of the outside portion of that section, thus giving strength to what, paradoxical thought it may appear, to the uninitiated, is inherently weak on account of its proportionately great thickness. The use of chills under some circumstances, then, may materially aid in giving strength to places in a casting which otherwise would be liable to weakness, but their application must be the subject of careful consideration, or undue hardness will result, particularly if the section is not particularly heavy. A good surface may readily be obtained at the expense of those qualities which are appreciated in the machine shop, and when friction occurs between that department and the foundry, the moulder frequently proves to be "bottom dog."

London Branch of the British Foundrymen's Association.

We have at various times strongly supported the claims for a London Branch of the British Foundrymen's Association, and now that proposal bids fair to materialise. At the invitation of Mr. T. Murphy, a number of gentlemen prominently connected with the foundry industry met recently to consider the matter, and it was decided unanimously that the parent body of the British Foundrymen's Association be approached with a view to assisting the formation of a London Branch. Mr. Murphy, 21a, Brooksby Street, London, N., was appointed secretary of the proposed Branch, and intimated that he would be very pleased to hear from any person interested in the matter.

The subject was considered by the Council of the Association on January 7th, and that body decided

to give their whole support to the proposal. A strong local committee is being formed, and support is promised from the foundry staff of Messrs. Fraser & Chalmers, Erith, Kent; Messrs. Dewrance & Company, London; Messrs. J. I. Thornycroft & Sons, Southampton; Messrs. J. Oswald & Sons, London; Messrs. Gwynne & Company, London; Great Western Railway, Swindon; Messrs. G. Aston & Sons, London; The Albany Engineering Company, London; Rodney Foundry Company, London, and several other influential firms. The President of the parent Association, Mr. Percy Longmuir, B.Met., and several members of the council have decided to go to London to the first meeting, which will be held at an early date. That London is sufficiently a foundry centre to support a good Branch cannot be doubted for one moment; for within the London County alone there are over eighty iron foundries, employing between 500 and 700 men; and in addition there are about the same number of brass foundries. These are apart from the numerous foundry works in the south-eastern counties, which would naturally attach themselves to a London Branch, if to any at all. As regards members working in the London district, they are particularly well situated for attending meetings; with the extensive systems of trains, both steam and electric, electric tram-cars and motor-buses, which are available, it is a simple matter to get from any point to the centre. This should materially assist in securing members from all round the Capital, and it is not without some grounds that we look for a very prosperous London Branch of the Association.

British Foundrymen's Association: Lancashire Branch.

The third annual dinner of the Lancashire Branch of the British Foundrymen's Association was held on Saturday, January 14, at the Victoria Hotel, Manchester, Mr. R. W. Kenyon (the President of the Branch) in the chair. The event was the most successful of the kind ever held, the number in attendance being 75, or more than double those taking part in a similar function a year ago. The visitors included Professor H. C. H. Carpenter, M.A., Ph.D., Mr E. L. Rhead, F.I.C., F.C.S., Mr. J. H. Reynolds M.Sc., and Mr. J. E. H. Allbut, A.M.I.M.E (General Secretary of the Association)

The PRESIDENT, in his speech of welcome, warmly congratulated the members on the great progress that had been made. He hoped that they would increasingly take advantage of, and apply the scientific knowledge now placed at their service. They had succeeded in developing a spirit of intelligent inquiry among actual foundry workers, and they were already supplying thoroughly trained and well-equipped foremen and managers. The effect must ultimately be to increase profits. He hoped eventually the heads of great industrial undertakings would feel it their duty to help, by their countenance and by practical subscription.

MR. E. L. RHEAD proposed the toast of "The British Foundrymen's Association." While he congratulated the foundrymen on their great skill as craftsmen and their knowledge of material, due to training and tradition, he urged the necessity of scientific training to get rid of irregularities and uncertainties. There was a great amount of accumulated knowledge that could be applied in the foundry, but they needed to cultivate something of the freedom in the communication of knowledge which was such a feature of American trades.

MR. J. E. H. ALLBUT, responding, congratulated the Lancashire Branch on its enthusiasm and rapid progress. Referring to the parent organisation, he said they now had on the roll 600 members, and he hoped by the end of the year they would attain four figures; there was a great increase in revenue, which he attributed to the alteration in the basis of membership. He had every hope that the new Glasgow Association would prove a large one. At the last meeting of that Branch 300 attended. A Branch was about to be commenced in the London district, and promises of support had been received from workers connected with a large number of London firms. To encourage the giving of papers, the Council had decided to award a diploma for the best paper of the year, and the scheme for this would be considered at the Glasgow conference in August next. The "Proceedings" for 1910 would be issued shortly, and would contain a large amount of very valuable matter. The Association, as a whole, was making very rapid and most satisfactory progress.

The toast of "The Lancashire Branch" was proposed by MR. G. N. SHAWCROSS (Assistant Works Manager of the Lancashire and Yorkshire Railway at Horwich). The speaker strongly urged the foundrymen to reduce the wastages still going on in the foundry. He congratulated the members on the greatly improved status attained within the last ten years. Formerly visitors were not shown the foundry, but now it was often first inquired for as one of the most important departments.

MR. W. H. SHERBURN, responding, congratulated the members on the rapid growth from the small beginning of five members five years ago. They now had 100 enrolled, but there were still scores of men available. In a very happy way, the Association had brought in moulders, casters, draughtsmen, and men of science. The speaker acknowledged the great assistance received from representatives of the University and the School of Technology, the latter building having been their home since the commencement of the Branch.

The toast of "The Visitors" was proposed by MR. MAXWELL S. KENYON, who testified to the excellence of the technical training obtainable in Manchester.

PROFESSOR H. C. H. CARPENTER responded, referring to founding as one of the oldest crafts in the world. It was specially important in Manchester as the largest engineering centre in the country. The foundry was the rock bottom of successful engineering practice. They were hoping so to develop the School of Technology and the University as to make these institutions of great service to foundrymen. At the University, they were arranging to have a foundry developed on scientific lines, which would prove of service to practical founders, both in iron and non-ferrous metals.

Mr. J. H. REYNOLDS also responded. An American, he said, expressed to him his astonishment at the great capacity of Englishmen, but remarked, "Why do not they add to that capacity, knowledge. Then there would be no nation under heaven that could beat them." The country was greatly suffering because competing nations like Germany were spending much more on research than Englishmen were prepared to spend. What they wanted was free trade in knowledge.

The toast of "The Press" was proposed by MR. F. PENLINGTON, who spoke appreciatively of the great help rendered by the FOUNDRY TRADE JOURNAL to the Association, and responded to by MR. J. MILLS PALMER and MR. J. HORTON (of the FOUNDRY TRADE JOURNAL).

An excellent musical programme was given by Messrs. G. W. Wilson, J. G. Robinson, A. Willman, S. Schofield, G. G. Barnes, and T. W. Holt.

Manganese in Cast Iron and the Volume Changes During Cooling.*

By H. I. Coe, M.Sc. (Birmingham),

(*Concluded from page* 20.)

II. THE EFFECT OF MANGANESE ON THE VOLUME CHANGES OF GREY IRON.

The materials used were as follows:—

(A.) *Grey Iron.*—A pig of Blaenavon hematite iron was taken from a stock used in the Siemens' open-hearth furnace of the University; its fracture showed it to be a No. 1 or No. 2 iron, and analysis gave the following results:—Total carbon, 3.71 per cent.; graphite, 3.45 per cent.; combined carbon, 0.26 per cent.; manganese, 1.07 per cent.; silicon, 2.45 per cent.; sulphur, 0.028 per cent.; phosphorus, 0.053 per cent. The manganese was unfortunately high, but the difficulty was to a certain extent overcome by using an iron containing similar silicon and carbon, with just over 0.5 per cent. manganese for the first casting.

TABLE VI.

Bar.	Total Carbon.	Graphitic Carbon.	Combined Carbon.	Manganese.	Silicon.	Inches Expansion.	Remarks.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	
	4·01	...	4·01	31·50	2·80	...	Original manganese alloy.
	3·71	3·45	0·26	1·07	2·45	...	Original pig iron.
A	3·66	2·67	0·79	0·55	2·45	0·01931	S=0·08 p. ct. P=0·06 p. ct.
B	3·70	3·39	0·31	1·00	2·46	0·02628	Slightly depressed gate.
C	3·63	3·16	0·47	1·61	2·35	0·01396	Slightly larger depression.
D	3·60	3·25	0·35	2·23	2·35	0·01836	Very small depression.
E	3·60	3·33	0·27	2·65	2·39	0·01907	Fairly large depression.
F	3·70	3·12	0·58	3·45	2·48	0·01943	Considerable piping.
G	3·80	2·94	0·86	4·19	2·44	0·02140	Do.
H	3·12	2·69	0·43	5·15	2·40	0·01861	Do.
K	3·40	2·85	0·75	5·83	2·34	0·01931	Do.
M	3·24	2·60	0·64	6·62	2·40	0·02280	Even depression in gate.
N	3·85	2·15	1·70	8·35	2·28	0·01977	Do.
O	3·85	2·10	1·73	9·89	2·45	0·03662	Do.
P	3·25	1·98	1·27	10·30	2·41	0·02564	Deep piping.
R	4·00	1·65	2·15	11·15	2·48	0·02256	Very deep piping.
T	4·28	1·14	3·11	17·57	2·54	0·03273	Moderate piping.
U	3·89	nil	3·89	30·30	2·96	0·01165	White fracture. Deep pipe.

The next step was to prepare an alloy rich in manganese, and containing a similar total carbon and silicon, so that these two elements should vary as little as possible throughout the series. This was effected by melting together the following quantities of the rich ferro-manganese and mild steel (used in the white iron series) with a 20 per cent. ferro-silicon:—Ferro-manganese, 8 lbs. 4 ozs.; mild steel, 9 lbs. 6¾ ozs.; 20 per cent. ferro-silicon, 2 lbs. 12¾ ozs., calculated to give an alloy containing 2.9 per cent. carbon and 2.8 silicon. It was assumed that about 0.8 per cent. carbon would be taken up from the salamander pot in which the alloy was melted, and that 0.35 per cent. silicon would be oxidised during melting. Both these assumptions were shown to be erroneous, as the following analysis indicates that not only is a larger quantity of carbon taken up by the alloy, but also that no silicon at all is oxidised.

The mixture was introduced into a 56-lb. salamander pot, melted in a wind furnace, and the molten alloy cast into iron moulds; quite a large amount of dark brown glassy slag having a red micaceous-looking surface was formed, and the alloy itself presented a very crystalline and columnar structure, the fractured columns showing a granular silvery appearance. The alloy was extremely weak,

TABLE VII.

Bar.	Manganese.	Ar_1.	Freezing Point.
	Per Cent.	Degrees C.	Degrees C.
A	0·55	...	1136
B	1·00	698	1138
C	1·61	690	1142
D	2·23	...	1150
E	2·65	655	...
F	3·45	650	1143
G	4·19	Not detected by 350	1145

and crushed up to a fine powder very readily in the steel mortar, and inch-thick slabs dropped on a stone floor broke readily. Analysis gave the following results:—Total carbon, 4.01 per cent.; graphitic carbon, *nil*; combined carbon, 4.01 per cent.; manganese, 31.50 per cent.; silicon, 2.80 per cent.; phosphorus, 0.092 per cent.; sulphur, 0.006 per cent.

Casting the Bars.—The experiments were carried out in exactly the same manner as in the white-iron series, except that larger quantities of metal had to be melted in the pot to give an amount sufficient to fill the mould; thus with ordinary grey iron, 70 ozs. of metal were put in the pot to give a bar weighing just over 40 ozs.

The loss was due to a thick scum and kish which formed on the surface of the metal during melting, and which kept back a considerable amount of metal when the cast was made. There was no trouble in this series caused by the corrosive power of the alloys rich in manganese on the walls of the crucible, a property which in the previous experiments had often caused some annoyance by permitting the molten metal to run into the ashes. The presence of 2½ per cent. of silicon in the iron may have protected the crucible considerably.

Table VI. gives the analysis of the cast bars with

TABLE VIII.

Bar	Manganese.	Shrinkage.	Bar.	Manganese.	Shrinkage.
	Per Cent.	Inches.		Per Cent.	Inches.
B	1·00	0·108	H	5·15	0·157
C	1·61	0·122	M	6·62	0·170
E	2·65	0·128	O	9·89	0·183
F	3·45	0·121	R	11·15	0·209
G	4·19	0·151	T	17·51	0·209
			U	30·30	0·235

their expansions during solidification. The expansion curves of this series will be found drawn in Fig. 5.

There is a considerable difference in the properties of Bars A and B, although the manganese varies

* "Journal of the Iron and Steel Institute," 1906, No. II., p. 6

by only 0.5 per cent. While the total carbon in both is practically the same, the relative proportions of free and combined carbon differ considerably, as the analyses show; again, the fractures of the two bars cast under similar conditions are quite unlike one another, that of Bar A being dull black and amorphous, whilst that of Bar B glistens with tiny flakes of graphite and is more open. It must be remembered, however, that the two bars were cast from different pig-irons, although the compositions of these pigs were similar.

The addition of manganese to the original 1 per cent. material whitens the fracture perceptibly, although with 2.65 per cent. manganese there appears to be a slight darkening again; but more than 4 per cent. whitens the metal once more, and at the same time the grain becomes much finer. Bar M (6.6 per cent. manganese) begins to show traces

TABLE IX.

Bar.	Manganese.	Hardness.	Bar.	Manganese.	Hardness.
	Per Cent.			Per Cent.	
A	0·55	20	K	5·89	56
B	1·00	37	M	6·62	58
C	1·61	40	N	8·35	63
D	2·23	38	O	9·89	66
E	2·65	33	P	10·30	67
F	3·45	42	R	11·15	65
G	4·19	53	T	17·51	87
H	5·15	56			

of mottling, and this appearance becomes more definite with increase in manganese. Bar O (9.9 per cent. manganese) is mottled and very crystalline, though P and R are less crystalline; but Bar T (17.5 per cent. manganese) is very spiegel-like, and shows but little graphite mottling the surface of its fracture. It may be confidently asserted that a siliceous iron may be called definitely grey, and yet contain as much as 8 per cent. of manganese.

The strength of these irons could not be estimated even very roughly by means of the sledge-hammer, and it is only possible to say that they become weaker when their fractures become crystalline, so with over 10 per cent. manganese they are readily broken, although even these alloys are not crushed as easily as the white irons.

The effect of manganese on the hardness of grey iron is very interesting, and relative figures will be given in a later paragraph; sufficient to state that up to 3.45 per cent. manganese the metals were readily sawn and drilled, though undoubtedly increasing in hardness. Bar G (4.19 per cent.), however, could be touched by neither saw nor drill, and the surface was with difficulty shaped; with more than this amount of manganese the alloys were in-

TABLE X.

Bar.	Manganese.	Height.	Thickness.	Area.	Breaking Load.
	Per Cent.	Inches.	Inches.		Tons per Sq. In.
B	1·00	1·25	0·633	0·305	37·34
E	2·65	1·25	0·635	0·306	43·27
F	3·45	1·25	0·638	0·404	46·91

tensely hard, but at the same time retained a considerable measure of toughness.

The residues left in the pots after casting the bars present some interesting points. The iron used for casting Bar A left a large amount of oxidised material, which appeared as a thick scum; the residue after casting Bar B was composed of scum and large quantities of "kish" or fine graphite. Although three and a-half ounces of kish, consisting of graphite mixed with shots of metal, were taken out of the pot used for melting Bar B, it is astonishing to find that the total carbon in the cast bar is just the same as in the original metal. This residue of kish and scum presents much the same features up to 5 per cent. manganese, after which it decreases until Bar T (17.6 per cent.) leaves behind only traces on the surface of the residual button. The fracture of this latter shows the slightly mottled crystalline appearance of the corresponding bar. The author is unable to account for the sudden decrease in total carbon in Bars H, K, and M.

The Effect of Manganese on the Condition of the Carbon.

The prevailing idea as to the effect of manganese on the condition of carbon in cast iron is that manganese exerts an immediate whitening action, and that 3 or 4 per cent. will convert a grey iron into a perfectly white iron. Keep,* it is true, draws attention to this erroneous idea, and gives examples of irons very rich in manganese being grey. It is hoped that the experiments under consideration will give convincing evidence as to the exact whitening effect of manganese on grey cast iron.

It may be repeated that the alloy with 8 per cent. of manganese is definitely grey, and that with 17.5 per cent. distinct mottling is evident. For the purpose of proving that the graphite in the latter case was not a result of mechanical mixture during casting, pieces were remelted in a crucible and cooled slowly; the fracture remained identical, and no kish rose to the surface.

If one turns to the analyses, one sees that although there may be at first a slight increase in carbide, the iron contains as much graphite relatively to combined carbon with 2.65 per cent. manganese as with 1 per cent.; beyond 2.65 per cent. the proportion of combined carbon steadily increases until with 17 per cent. of manganese it forms three-quarters of the total carbon. The cast alloy with 30 per cent. manganese is perfectly white.

Structurally free carbide is first apparent under the microscope in Bar K (5.83 per cent. manganese), and probably separates as a definite constituent at close on 5.5 per cent. manganese.

Pyrometric Results.

Reduced curves are given in conjunction with the corresponding expansion curves in Fig 5, and from them it will be seen that the arrests on solidification are definitely indicated in every case except Bar E. Unfortunately, the experience in the case of the white irons does not give one confidence in accepting the sudden drop at 5.15 per cent. manganese, although a slow cooling curve of Bar T, 17.5 per cent., gave the freezing point as 1,094 degrees C. as compared with 1,092 degrees C. obtained from the colling curve of the casting. However, it may be said with some degree of assurance that the addition of manganese up to 4 per cent. raises the melting point, but further increase to 17 per cent. lowers this point.

A study of the pearlite points is interesting, and it will be found that, although the amount of pearlite is not as great as in the white irons, the heat evolution at the arrest point, Ar_1, in the case of the grey irons is much greater, and results in a true recalescence amounting to about 10 degrees C.

The thermo-couple, in the case of Bars A and D, after recording to 700 degrees C., snapped at the junction before the pearlite point was indicated, and time has not permitted of repeating the cooling curves.

* Keep, "Cast Iron," p. 100.

Table VII. gives the temperatures of pearlite formation with varying percentages of manganese, and it will be observed that the action of manganese is similar, in its lowering of Ar_1, to its effect in the case of the white irons.

The pearlite arrest point, however, disappears abruptly with less than 4 per cent. manganese, and does not tend to fade away, as in the case with the white irons.

Undoubtedly the evolution of heat at this temperature is not connected solely with the formation of pearlite, but is also connected with the separation of a secondary graphite or temper carbon. This is a point that may be discussed more fitly later.

Microscopic Investigation.

Microsections of the original materials were first prepared and examined; the pig-iron containing 1

FIG. 18.—HEMATITE PIG. 100 DIAMETERS. 1.07 PER CENT. MN; 2.45 PER CENT. SI. FERRITE, GRAPHITE, AND PEARLITE.

per cent. manganese showed the normal grey iron structure (Fig. 18), consisting of large flakes of graphite traversing areas of ferrite and bordering patches of pearlite. Some secondary graphite occurs, and the grain may be described as quite coarse.

The 30 per cent. manganese alloy has quite a brilliant appearance, as is shown in Fig 19, and consists of needles of carbide (?) in a matrix of extremely fine needles. A peculiar feature of this alloys lies in the eutectic-like fringe that occurs along the edges of the large needles. The correct etching of the cast bars gave some difficulty, as they stained readily, and the pearlite was, at best, but poorly developed.

The microstructure of Bar B makes an interesting comparison with that of the original pig-iron, as illustrating the effect of rapid cooling on grey iron.

Figs. 18 and 20, the one at 100 diameters, the other at 400 diameters, will help to illustrate this difference, and from them it will be seen that in the cast material ferrite has practically disappeared, and that fine flakes of graphite replace the coarser flakes and form a network around ground-mass of pearlite. In other words, it may be said that in the cast bar the grain is finer and more homogeneous.

The microstructure up to 3.5 per cent. manganese does not alter appreciably, save that the pearlite tends to become more granular. Unetched and under a low power, these specimens show just a trace of dendritic structure (possibly due to the concentration of the silicon in certain crystals), and also a network of graphite, flakes of which often radiate out from a dull black central portion.

These dull black spots were plainly visible to the naked eye, particularly in specimens G. and H. (4.5 per cent. manganese), in which flakes of bluish graphite seem to rest in a darker material partaking of the nature of secondary graphite; observation under low power indicates that this secondary graphite can be dug out with the point of a needle. In these latter specimens pearlite appeared to have been replaced by a solid solution cut across by very faint white lines, so confirming pyrometric records. With just over 5.5 per cent. manganese a definite carbide makes its appearance in the form of a spray-like eutectic, as seen in Fig. 22, which shows a localised area, and increase in manganese causes this eutectic to become more prominent until with 17.5 per cent. manganese (Fig. 24) it appears to make up nearly the whole mass of the section. Fig. 23 of Bar O (9.9 per cent. manganese) shows this eutectic in conjunction with structurally free solid solution, the latter containing flakes of graphite and amorphous carbon in its mass. Actual flakes of graphite are not visible in alloys containing more than 12 per cent. manganese, though the black amorphous form may still be observed. The explanation of the structures

FIG. 19.—MANGANESE ALLOY. 100 DIAMETERS. 31.5 PER CENT. MN.; 2.8 PER CENT. SI; 4.0 PER CENT. C.

shown under the microscope is naturally a matter of great difficulty as the system is really a quaternary one, iron, manganese, carbon, and silicon all entering into the complex.

The main questions that arise are—(1) What is the constitution of the metal before free carbide appears? (2) What is the constitution of the carbide, and particularly the eutectic that makes up Bar T (17.5 per cent. manganese)?

The answer to the first question might reasonably be a solution of the double carbide, $8Fe_3C.Mn_3C$, and of the double silicide, $Fe_2Si.Mn_2Si$, in excess of iron. The free carbide first appears in K, so taking a mean of Bars H and K at 0.60 combined carbon, 2.37 silicon and 5.50 manganese, the solution would be uniform and saturated with the above compounds; 0.6 per

cent. combined carbon would absorb 1 per cent. manganese to form double carbide, and 2.37 per cent. silicon would absorb 4.7 per cent. manganese as double silicide. That is, the total manganese taken into solution by these elements would be 5.7 per cent., which is not far different from the figure 5.50 given.

The author is unwilling to venture a reply to the second question.

The Volume Changes of the Grey Irons.

From the curves which are reproduced in Fig. 5, it will be seen that the expansions on solidification cannot be linked up to form a definite curve, such as was found for the white iron series. An examination of any single expansion curve will show that there is a rapid rise in the curve until solidification is complete, followed by a sudden drop; in other words, that there is no gradual increase in the rate of shrinkage after the expansion, as found for white irons. This is what might be expected as the alloy solidifies at one temperature. The accepted explanation of this relatively large expansion is that it is due to the graphite that separates out on solidification; and yet it is seen that Bar T (17.5 per cent. manganese) possesses more than twice as large an expansion as C (1.66 per cent. manganese), although the free carbon is only one-third the amount in Bar C.

Bearing in mind that the density of graphite is to that of iron almost in the ratio of 1 to 4, it will be seen that if the former separates between the crystals of iron, an increase in volume will result; and taking for example Bar B, with 3.4 per cent. graphite, this latter on solidification would occupy four times the space of its weight of iron. Thus the increase in volume caused by its separation would be

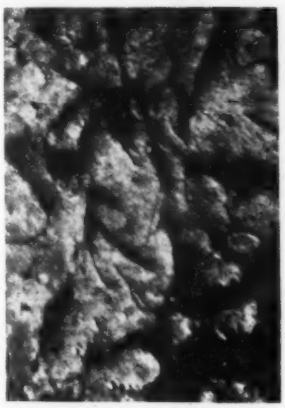


FIG. 20.—BAR B. 400 DIAMETERS. 1 PER CENT. MN. FINE PEARLITE AND SMALL FLAKES OF GRAPHITE. (*Cf.* FIG. 1.)

the volume of the graphite minus the volume of the same weight of iron; that is, the increase in volume will be three times 3.4=10.2 per cent. of the total volume, or say, 10 per cent.

Now Wrightson,* in a Paper to which reference has already been made, states on p. 21: "The average of six experiments shows that the No. 4 foundry iron in passing from the solid to the plastic condition expands in the proportion of 6.50 to 6.92 or 6.95 per cent. . . ." That is, allowing for the difference in the grades of the iron, it may be said that the calculated figure for expansion is not seriously wrong. According to this calculation, on a 12-in. bar the linear expansion on solidification should be 1.2 in.; but it is found that in Bar B the linear expansion is only 0.026 in., an effect which, according to calculation, should be produced by $\frac{0.026}{1.2} \times 3.4$ per cent.= 0.073 per cent. graphite.

Ordinary experience would indicate that such an enormous expansion as 10 per cent. is impossible in solid or semi-solid cast iron, and though it is possible that the graphite may separate in the metal while still quite fluid, further experiments will have to be performed before any definite conclusions can be drawn

FIG. 21.—BAR C. 400 DIAMETERS. 1.66 PER CENT. MN. MORE GRANULAR PEARLITE.

with regard to the volume changes during the solidification of grey cast irons.

Considerable information as to the separation of secondary graphite during cooling may perhaps be derived from a study of the extensometer curves.

If Bar 3 (0.88 per cent. manganese) of the white iron series be compared with Bar B (1.00 per cent. manganese) of the grey iron series, it will be observed that in the range of temperature from solidification to 650 degrees C. (that is, below Ar_1) the former shrinks 0.13 in., whilst the latter is just the same size as when cast; or, deducting the expansion during solidification, has only shrunk 0.026 in. during the period from the end of solidification to 650 degrees C.

Furthermore, the rate of shrinkage in the former case is practically the same per 100 degrees C. before and after Ar_1 is reached, whereas in the latter case the rate of shrinkage is found by measurement to be three times as great below Ar_1 as it was above that point. Now, if no secondary graphite were deposited in the interval between complete solidification and Ar_1, it is only reasonable to assume that the rate of shrinkage above and below Ar_1 should be somewhat similar; that is, by measurement the volume of the deposited secondary graphite should be roughly gauged. The linear effect of this secondary graphite will be 0.047 in., and this for previous reasons will be caused by the separation of 0.133 per cent. secondary graphite.

This argument is doubtless somewhat strained, and is only put forward to draw attention to a difficult subject that may perhaps be investigated with success by means of the extensometer.

A study of the expansion curves will show a re-

* "Journal of the Iron and Steel Institute," 1880, No. I., p. 11.

latively large and prolonged expansion at the arrest point Ar_1. It is unlikely that such an expansion is produced by the heat evolved at this point, but more probably the expansion is the outcome of a separation of some material from solution, in this case probably carbon. Iron, as is well known, is able to hold carbon in solution, as such or as carbide, above Ar_1, but at this point on cooling all such carbon is thrown out, usually in the form of pearlite. In the presence of silicon, however, the tendency to the separation of carbide is diminished, with the result that free carbon probably separates as well as pearlite.

Professor Turner pointed out, in a lecture to the Birmingham Metallurgical Society, that when a body is thrown out of solution there is a tendency to an increase in volume, and also that the change to a stable phase will be accompanied by a greater increase in volume than will be the change to a metastable phase. Both these facts may be brought to bear in the present case. In the white irons, where pearlite is formed, no actual expansion occurs at Ar_1, even though there is a tendency to an increase in volume. In the grey irons, where the change is, partially at any rate, to the more stable state of graphite, a relatively large increase in volume is registered. Again, the greater evolution of heat in the second case shows that the graphite state is more stable than the carbide state.

An observation made in connection with the shrinkage curves was that in every bar there was a slight though somewhat prolonged arrest in the rate of shrinkage at about 890 degrees C., and another, not as well defined, at 570 degrees C.; this latter arrest was not detected on all the curves, and neither arrest was indicated on the cooling curves.

These arrests may correspond to those detected by Messrs. Carpenter and Keeling* on the cooling curves of high carbon-iron alloys, though perhaps the first arrest may be due to a trace of phosphorus in the iron. It may be noted that these arrests were not found in the white iron series.

The Total Shrinkage.

The total shrinkage of certain of the grey irons was found by allowing the metal to cool down in the mould to the ordinary temperature, the extensometer being still attached; the difference between the readings at the moment of casting and when cold gave the total shrinkage.

The total shrinkages are given in Table VIII., and are drawn in Fig. 6, from which it will be seen that manganese increases the shrinkage by making the grain closer; the alloy with 11.15 per cent. manganese has nearly twice the shrinkage of the original metal with 1 per cent.

The Relative Hardness.

Specimens were sawn off the bars when possible (that is, up to 3.5 per cent. manganese), and a rough polish put on, but when the metal became too hard to saw, a flat face was ground down on an emery wheel. The hardness of the cross sections of the sawn specimens was taken, but it was found more convenient in the case of the hard specimens to determine the hardness just below the surface skin. It was shown by experiment that the differences thus involved were not greater than those over the face of the same specimen, as indicated by the sceleroscope. Table IX. gives the relative hardness of the various specimens, and the results are epitomised in Fig. 7.

The hardness increases with the first addition of manganese, then falls with 2 per cent., with a sharp rise at about 4 per cent., where the pearlite point disappears, after which it increases uniformly. The decrease in hardness at about 2 per cent. manganese corresponds to a diminution of combined carbon in the metal, and once again emphasises the fact that a pig containing 1 per cent. of manganese is not appreciably hardened by the addition of another ½ per cent.

It is interesting to note that the original pig from which Bar B was cast possesses a relative hardness of only 20; the increased hardness of the cast bar is due to the much closer grain that was mentioned in the microscopic section. Unfortunately for the series, the hardness of Bar A cannot be used for comparison for reasons previously stated.

Crushing Tests.

Professor S. M. Dixon, of the University, Birmingham, very kindly performed crushing tests of three of the grey iron specimens, and obtained the results given in Table X.

Summary.

I. The White Iron Series.

(*a*) The effect of manganese on the volume changes of white iron during solidification is to produce expansions that form a regular curve with the percentage of manganese, which curve shows minima at:—

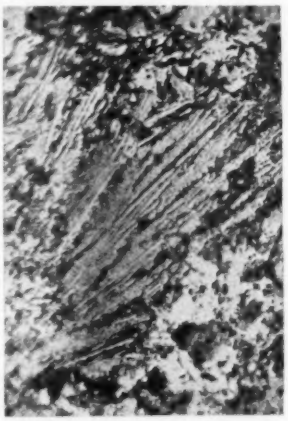


Fig. 22.—Bar K. 5.83 Per Cent. Mn. 400 Diameters. First Appearance of Free Carbide. Also Solid Solution and Graphite.

(1.) 0 per cent. manganese, corresponding to the existence of pure Fe_3C.
(2.) 5 per cent. manganese, corresponding to the existence of $8Fe_3C.Mn_3C$.
(3.) 15.3 per cent. manganese, corresponding to the existence of $2Fe_3C.Mn_3C$.
(4.) 19 per cent. manganese, corresponding to the existence of $3Fe_3C.2Mn_3C$.

In addition to these minima the curve shows a depression at 10 per cent. manganese which may correspond to the carbide $4Fe_3C.Mn_3C$.

(*b*) Pyrometric results show that, independently of carbon, manganese appreciably lowers the temperature at which the primary crystals separate out from the molten metal, though up to 20 per cent. manganese the temperature of solidification of the eutectic is not affected. Further addition of manganese lowers the eutectic point slightly.

(*c*) Pyrometric and microscopic data seem to indicate

* "The Range of Solidification and the Critical Changes of the Iron-Carbon Alloys," Journal of the Iron and Steel Institute," 1904, No. I., p. 224.

the existence of practically pure eutectic with 4.05 per cent. carbon, 26 to 28 per cent. of manganese, and 68 per cent. of iron, this eutectic probably consisting of the carbide $Fe_3C.Mn_3C$ and a solution of this carbide in iron. The freezing-point of this eutectic is 15 degrees C. below that of the pure iron-carbon system.

(*d*) On increasing the manganese above 30.5 per cent. excess carbide separates out in bands, even though the carbon does not increase; this separation is registered on the cooling curve.

(*e*) Manganese lowers the temperature of the arrest-point Ar_1 by about 20 degrees C. for each 1 per cent. of manganese added, and the intensity of this arrest tends to fade away with increase in manganese, disappearing probably at 10 per cent.

(*f*) The pearlite itself becomes finer and more sorbitic up to 5 per cent. manganese, and the separation of free carbide takes place across the solid solution, possibly along crystal boundaries, in the form of canal-like bands.

(*g*) Above 5 per cent. manganese the solid solution

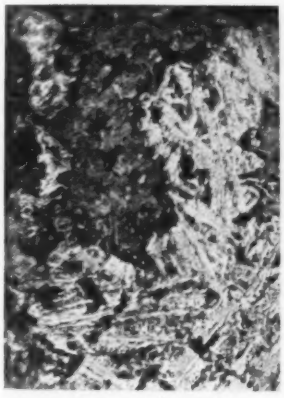


FIG. 23.—BAR O. 0.89 PER CENT. MN. 400 DIAMETERS. EUTECTIC + SOLID SOLUTION, CONTAINING FLAKES AND SPOTS OF GRAPHITE.

remains unchanged down to the ordinary temperature, save for a slight breaking down round the edges between 5 and 10 per cent.

(*h*) The hardness of the series increases up to 6.3 per cent., falls with a sudden drop to 12 per cent., after which it rises, and with a slight temporary decrease at 19 per cent., remains uniform above 23 per cent.

II. THE GREY IRON SERIES.

(*a*) The expansion on solidification was in every case relatively large, but the results did not permit of a definite curve being deduced. After a drop at 1.6 per cent. the expansion was greater with increase in manganese reaching a maximum at 10 per cent. after which it fell away, rising once more as the manganese reached 17.5 per cent.

(*b*) The temperature of solidification of the alloys showed a tendency to rise with the addition of the first few per cent. of manganese; further addition produced a fall of 50 degrees C. to 1,100 degrees C., this latter figure representing closely the freezing point of alloys containing from 7 to 17.5 per cent. manganese.

(*c*) The pearlite point disappeared suddenly with 3½ to 4 per cent. manganese, and subsequent microscopic examination confirmed this point.

(*d*) Microscopic examination also showed the occurrence at 5.8 per cent. manganese of free carbide as a constituent of an eutectic, and this eutectic increases in bulk until with 17.5 per cent. manganese it appeared to make up the main mass of the section. Further addition of manganese causes free carbide to separate out in acicular crystals.

(*e*) The disappearance of graphite with a concomitant increase in combined carbon, did not appear to occur appreciably until the manganese reached 3 per cent., after which the one disappeared fairly uniformly with an equivalent increase in the latter. Even with 17.5 per cent. manganese there was a perceptible amount of free carbon present.

(*f*) The shrinkage of the grey irons increased with increase in manganese, but in no case was it as great as in the white iron series, probably owing to the formation of secondary graphite during cooling.

(*g*) The hardness of the specimens increased with the manganese up to 2 per cent., and then after falling to 2.65 per cent. rose suddenly to 4 per cent. prior to a uniform rise through the series.

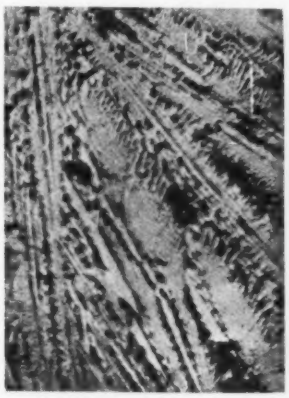


FIG 24.—BAR T. 17.51 PER CENT. MN. 400 DIAMETERS. JUST HYPO-EUTECTIC. SOME SPOTS OF AMORPHOUS GRAPHITE.

APPENDIX A.

Analysis of the Bars.

Total Carbon was estimated by introducing two grammes of the finely crushed (90 sieve) metal, placed in a fire-clay boat, into a silica tube at a bright red heat and combusting in a stream of oxygen, the carbon dioxide formed being collected and weighed as described by Arnold and Ibbotson.* It was found that 15 or 20 minutes were sufficient for combustion.

Graphite.—By dissolving in nitric acid (specific gravity 1.2), filtering on to asbestos, and burning in silica tubes.

Combined Carbon.—By subtraction. Eggertz' colour test is unreliable in this case, owing to the presence of manganese conferring a lighter colour on the solution. For example, the alloy containing 40 per cent. manganese and 3.8 per cent. carbon gave only 2.2 per cent. carbon by the colour test, using the American washed iron as standard.

Silicon, Sulphur, and Phosphorus, by ordinary gravimetric methods.

Manganese.—The most reliable method was found to be the ammonium acetate separation. In the high-manganese alloys neutralisation was completed by the addition of ammonium carbonate; the method of fractional filtration described by Arnold and Ibbotson was used in every case.

* "Steel Works Analysis."

Integrity of Tests of Metals.*

By Alexander E. Outerbridge, Jr.†

There is no subject of greater interest and importance in the metallurgical arts than that of testing metals. Upon the integrity of these tests rests the stability of all the immense modern structures composed of iron, steel, bronze and other metals; human life depends in many instances upon the reliability of tests made in the laboratories of "coupons" cut from full size sections, in some cases, or from small bars—usually cast attached to larger masses—in other cases.

These coupons, or test-pieces, are supposed to fairly represent the average tensile and transverse strength, the ductility or resilience (*i.e.*, ability to resist shock), the micro-structure of the metal and, in a word, to reveal the true physical properties of the material entering into any given structure. Have we arrived at a degree of perfection in the art of testing metals that enables us to rely with confidence upon such records? I fear not.

So far as the development of various machines for accurately testing the tensile strength, transverse strength, torsional strains, and so forth, of metals is concerned, a very high degree of sensitiveness combined with accuracy has been arrived at by many constructors of such apparatus, but if the specimens tested do not in all cases fairly represent the quality of the material in the mass the records may be, and often are, misleading.

My own investigations, extending over a period of nearly 40 years, have convinced me that coupons or test-pieces do not always represent truly the strength, molecular structure, resilience, etc., of the material to which they may be attached and to which they are supposed to conform closely in physical properties, for the following reasons among others.

Metals in their pure state are not employed in engineering constructions, all are more or less heterogeneous compounds, or alloys, and all alloys (with perhaps a single exception, viz., gold and copper) tend to "segregate" or separate in the process of cooling from the liquid to the solid condition into richer and poorer alloys, one particular combination usually forming what is known technically as the "eutectic."

In the case of the standard gold alloy for coin (nine parts gold, one part copper) no precautions of this kind are needed, for the simple reason that this alloy does not segregate, and chips taken from the edge and from the centre of a double-eagle will conform to the legal requirements, notwithstanding that they are very much more strict than in the case of silver coin.

With respect to cast-iron it is no exaggeration to say that the rate of cooling of grey cast iron exerts as important an influence in determining its physical properties as does variation of its chemical constituents within, of course, certain quite wide limits. If a wedge-shaped bar be cast of ordinary foundry iron, say 6 ft. long, 6 in. wide, 6 in. thick at one end, and tapering in thickness to, say ¼ in. thick, almost every grade of cast iron may be found in the bar by nicking and breaking it into short sections, say 6 in. long each. At the thick end the fracture will be coarse grained or "open" with very dark colour due to the fact that almost all of the carbon is in the graphitic or "free" condition. At the thin end the fracture will be fine grained and light in colour, because a considerable portion of the carbon will be chemically combined with the iron. If test-bars be cut from these different sections, it will be observed that the coarse-grained metal is very soft under the tool, while test-bars cut from near the thin end will be very hard to turn. Between these two extremes the metal will have intermediate degrees of hardness and of coarse grainedness.

If tensile tests be made from different portions of the casting, it will be found that the strength varies with the structure through an enormous range, as much as 100 per cent. gain often occurring in one portion over another. If the ordinary foundry iron used for the wedge-shaped casting be low in silicon (say 1 per cent. or under) the thin end of the wedge will be as white as silver, as hard as steel, and as brittle as glass, because a large proportion of the carbon will then be in the combined form.

Take for example two test-bars of soft foundry iron used for casting light pulleys, poured from one small hand-ladle of iron into companion bars of the same size, viz., 1 in. by 1 in. by 15 in.; one bar was cooled normally in the "green" sand mould, the other was cooled very rapidly indeed. Both bars were broken transversely on an ordinary transverse testing machine, using a span of 12 in. One bar, cooled normally, broke under a strain of 2,000 lbs. (round figures); the other, cooled rapidly, at 4,000 lbs. exactly. One-half of each bar was then used for tensile tests, being turned to the same dimensions and pulled upon a 100,000-lb. hydraulic testing machine. The bar cooled normally showed tensile strength of 21,500 lbs. per square inch. The bar cooled rapidly showed tensile strength of 37,000 lbs. per square inch.

In a Paper giving some of the foregoing facts, read before the American Society for Testing Materials in 1903, published in the "Proceedings," the following conclusions were drawn:—

"The rate of cooling of cast iron from the fluid to the solid state is such an important factor in determining the physical properties of the metal, that it is just as necessary to know the dimensions of the test-bars as it is to know the chemical composition. For the same reason it is equally desirable that standard sizes of test-bars should be adopted, which would be suitable for different grades of iron."

Castings of iron and other metals are frequently made for the Government as well as for private engineering firms under specifications which sometimes tax the ability of the founder to meet pretty stiff requirements as to strength. In the absence of any specific rules as to the method of moulding the test-bars, or even as to their size, the temptation to a foundry foreman, who may have practical knowledge of the facts here noted, to "jockey" with the test-bars and thus insure that they will fully meet the requirements, is very great, and ought not in the interest of all to be continued longer.

There is still another method, now pretty well known, by which the transverse strength of cast-iron test-bars can be increased from 25 per cent., even up to nearly 50 per cent., without either rapid cooling of the metal or making any change in method of moulding. Instead of simply brushing off the loose sand from the test-bars with a wire scratch-brush, if they be placed in a "tumbling-barrel," commonly employed in foundries for cleaning castings, and tumbled about therein for a couple of hours, they will all gain largely in transverse strength, due, it is thought, partly if not mainly, to the rapid release

* "Journal" of the Franklin Institute.
† Professor of Metallurgy in Franklin Institute.

caused by shocks, of "cooling strains," and it has long been known that iron-castings improve in strength with age, due to gradual release of internal strains. When these peculiar observations were first made known, the custom of cleaning the sand from test-bars in the tumbling barrel became very popular indeed, and finally a few years ago, the American Society for Testing Materials found it desirable to incorporate a special clause in its new specifications for cast iron that test-bars must not be tumbled or otherwise subjected to mechanical shocks or vibrations before being broken. This was a gratifying tribute to the original discovery.

With regard to test-bars for bronze castings, similar restrictions should apply in regard to cooling, for segregation occurs in all commercial bronzes, depending largely upon the rate of cooling from the liquid to the solid state. This segregation changes the molecular structure and affects the tensile strength of the metals. Test pieces of bronze cooled much more rapidly than the castings to which they may be attached do not reveal the true character of the fracture, or the real strength of the metal. On the contrary, they present to the eye a finer grained, more uniform metal and show abnormal strength in the testing machine.

The conclusions drawn from investigations with bronze metals were quite similar to those already noted with respect to investigations in cast-iron, and are as follows:

1. Variations in treatment of specimens cause variations in the results, which may be misleading, and it would, therefore, seem desirable that some uniform system should be adopted by all investigators in this field.

2. The rate of cooling of a mass of metal affects the microstructure so that two specimens from the same ladle of metal, one taken from a small casting quickly cooled, the other from a large casting slowly cooled; or two photomicrographs taken from different portion of the same specimen, may show variations in microstructure that may lead to error.

It is desirable, therefore, that some uniform size of specimens (and uniform method of moulding) should be selected by micro-metallurgists as a standard with which to make comparisons.

British Foundrymen's Association: Birmingham Branch.

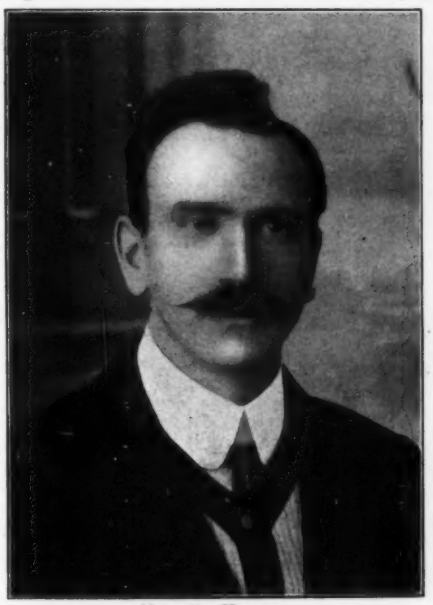
Presentation to Mr. C. Heggie.

The Birmingham Branch of the British Foundrymen's Association held its second annual Whist Drive on Saturday, January 14th, at the Pitman Hotel, and the gathering proved even a greater success than that held last year. The company, including ladies, number 106. An interval was agreeably filled in by an entertainment provided by members of the Branch and friends.

During an interval in the programme, Mr. H. L. Reason called upon Mr. R. Buchanan to make a presentation on behalf of the members of the Branch, to Mr. C. Heggie, on his retirement from the office of Honorary Secretary of the Branch.

Mr. Buchanan said that the Birmingham Branch of the Association desired to make some small recognition of the valuable services rendered by Mr. Heggie during his three years' secretaryship. All those acquainted with the work of the Association must know how much the success of the Branch had been due to the excellent services they had had from the various honorary secretaries who had served since its institution. They had first Mr. Cook, then Mr. Heggie, and now the duties were in the able hands of Mr. Hailstone. Presidents and vice-presidents might come and go, but, after all, the most important man in any Branch was the secretary. If he was a good organiser the success of the branch was very largely assured, and, unless the secretary was devoted to his work and thoroughly interested in the work, the branch was bound to be anything but a success. It was not necessary to enlarge upon the services of Mr. Heggie. They all knew that he had given his services ungrudgingly; but the work required considerable time and devotion, and, though it had been given freely and heartily, it was only right that they on their part should signify, in some special manner, their appreciation of it. (Applause.) In the name of the members of the Branch, he would ask Mr. Heggie to accept a polished oak case of table cutlery, supplied by G. Wolstenholm and Sons, Sheffield

The case bore a plate with the following inscription: "Presented to Mr. C. Heggie by the Members of the Birmingham Branch of the British Foundrymen's Association as a small token of appreciation of his services as Honorary Secretary, 1907-10."



Mr. C. Heggie.

Mr. Heggie, who was received with loud applause, thanked the members for their gift, which he said he should prize not only for its intrinsic value, but also as a memorial of his secretaryship, and as a reminder of many pleasant associations. He thanked Mr. Buchanan for what he had said in appreciation of his (Mr. Heggie's) work as secretary, and his fellow members for the hearty way in which they had endorsed those remarks. The work was a pleasure to him, and it was a greater pleasure to know that his efforts had met with the appreciation of his fellow members. As they all knew, their Association had grown very rapidly, and the Birmingham Branch had always held its own. The work, in fact, had so increased that, owing to other engagements he had felt that he could not continue to discharge the duties of honorary secretary. He felt sure that with Mr. Hailstone as secretary, the Branch would continue to progress, and to maintain its leading position in the Association. (Applause.)

Improved Cast Iron: How to Get it in the Foundry.*

By J. F. P. Lewis.†

Can the quality of cast iron be improved to an extent sufficient to raise its value and extend its function in the eyes of the mechanical engineer? The author claims that it can. During recent years cast iron has been gradually superseded for many important component parts of mechanical constructions by other metals and alloys. Is this entirely the result of the establishment of strength or physical quality specifications which under any circumstances would have put cast-iron out of court, or only partly the result of that, and partly the result of failures on the part of cast iron owing to its being inferior in its own kind or defectively manufactured? It is not possible at the moment to discuss the whole range of mechanical constructions, and where or where not it would be possible to employ cast iron; it will be sufficient to cite one or two concrete instances, in which there are good practical reasons for supposing that cast iron might have held against steel, wrought iron, phosphor-bronze, or some other more costly metal or alloy, certain ground which it has actually lost. For instance, hydraulic cylinders are made of steel which might have been constructed of cast iron without an unwieldly section, had the founder been able to guarantee a certain tensile strength well within the known compass of cast iron. Working and bearing parts of engines, such as slide-bars, motion-blocks, eccentrics, etc., are made of steel or case-hardened wrought iron where cast iron of the right hardness, tenacity, and density would have been equally, if not more, satisfactory. Steel is being more and more specified for superheated steam fittings, whilst careful experimenting shows that cast iron of the best quality is just as suitable. The more homogeneous and expensive metals are in use for parts of meters, freezing plant, and pneumatic engines, where iron is quite capable of meeting the necessities as regards density and strength, and sometimes highly expensive alloys are used for pots, retorts, kettles, and other vessels subject to strong acid or alkaline reactions, or to the penetrating or erosive action of fumes, gases, and vapours, where iron of the right chemical composition and properly manufactured would be, at any rate, a much more economical material.

The improved cast iron suitable for work of the foregoing descriptions must be superior to ordinary commercial qualities in the following respects:—It must have a much higher specific weight; it must be freer from those impurities, particularly free carbon, which interrupt the crystalline continuity of its structure; it must be more regular in its structure over large masses, that is to say, it must, though it cannot strictly be so, be much more nearly similar in physical character to the metallic condition known as solid solution.

An ordinary commercial cast iron will have a tensile strength of 8 or 9 tons per square inch, and a specially good iron will have a tensile strength of 12 tons, and the average specific density of grey iron castings will be about 7. If the ironfounder can turn out with certainty an iron having a constant tensile strength of 15 or 16 tons, and a constant specific density of 7.25, he will find that he has a material capable of competing with steel in many spheres where that metal now holds the field; providing this iron possesses certain wearing qualities which will be exhibited in its resistance to shock or abrasion, or to erosive actions, or to variations of temperature, or to intermittent stresses, and this combination of high tensile strength and high specific weight will almost certainly mean that it does possess these qualities. The author desires to show how such an iron can be turned out commercially in the foundry.

First, as to the much-vexed question of pig-iron and pig-iron mixtures, we may classify our choice of raw materials under three main headings:—(1) consisting of pig-irons of first smelting and scrap iron, *i.e.*, pig once cast; (2) consisting of either part pig-iron and part scrap iron, or pig-iron and scrap remelted, or wholly of remelted pig-iron, or of remelted pig and scrap; (3) of any of the preceding, along with steel or wrought iron in any shape or form. Of these three, the writer strongly advocates the first, *i.e.*, mixtures of pig-iron proper and scrap, and will give reasons for choosing this system and for rejecting the others. With reference to the mixing of steel, wrought iron, etc., the chief objection to this is that it throws a responsibility on the staff and plant in the foundry which the foundry are often unable to sustain. Additions of steel or other low-carbon material to cupola mixtures can only be successful where, firstly, the cupola is of the best design and the blower and air connections of the proper size and arranged on the proper system; and, secondly, where the foreman and moulders are skilled in carrying large bodies of metal almost immediately it is melted at very high temperature from the cupola to the moulding floor, and have the necessary equipment in the way of cranes, ladles, etc., to enable them so to do. The result of adding steel to iron in foundries where the cupola will not melt quick and hot, and where perhaps there are not even blowing facilities for such melting, and where there is no arrangement for disposing immediately of fairly large bodies of molten metal, is sure to be disappointing. A temperature sufficiently high properly to melt and fluidise the steel is not commanded, and it will not mix thoroughly with the iron, and through slow melting the steel will absorb great quantities of carbon and sulphur. This means a patchy casting, hard and soft, weak and strong, and probably containing more deleterious impurities than if nothing but iron had been melted. The author would like also to add, here, in relation to those cases of well-equipped and skilfully managed foundries, where mixtures of iron and steel *are* used with success as regards the density, homogeneity and strength of the castings produced, that such products will, from the important point of view of hardness and resistance to abrasion, be inferior to the best cast iron. Moreover, although tensile and transverse strengths may be considerably raised, they will not be raised consistently above the limits obtainable by iron alone unless the melting be done in an air furnace or a crucible.

With reference to that class of mixtures which consist wholly or partly of pig-iron, or pig-iron and scrap remelted, the author condemns that abso-

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† Frodair Iron and Steel Company, Limited,

lutely as a regular practice. The cupola furnace is not, in any sense of the word, a purifying furnace and should not be used as such. It is certain that what the founder may achieve in lowering silicon by remelting is at the cost of raising sulphur, and, furthermore, there will be in a well-blown, quick-melting cupola a considerable loss of the valuable element, manganese, in which only too many foundry irons are seriously lacking to begin with. The object of remelting is to reduce the silicon in the iron, and hence to close the grain. This object is achieved, but the process is a costly one, and if we assume the cost of melting iron in a cupola to amount all-told to 15s. per ton, it would seem distinctly possible for the founder to pay an extra 15s. per ton for his pig, and thereby obtain an iron of an analysis similar to that he expects to arrive at by remelting. The inverse relation between silicon and sulphur will almost certainly be constantly exhibited in any cast iron melted in contact with coke, but the smelter will have more skill and a greater choice of method in bringing down a low-silicon iron with a reasonable sulphur than the ordinary cupola hand will have, especially if you are willing to pay him 15s. a ton extra for his product. The alteration in the physical qualities of cast iron by melting is the direct result of the changes in the chemical composition due to melting, and these changes are almost impossible to control accurately in a cupola, and they will vary in their extent very considerably with variations in the composition and arrangement of the fuel or the iron charged, and with the oxidation to which the latter is exposed during the heat and the duration of the whole process. It, therefore, appears to be better to take originally pig-iron of the silicon and the approximate density required, holding a known sulphur, than to take a higher silicon pig than is necessary and melt it down twice, and this especially in consideration of the manganese which will be eliminated, since, if we scheme to keep up the manganese in our metal we must begin with pig carrying very high percentages of it, and such pig will be certainly very high in carbon.

To fall back on the old-fashioned system of mixing pig-irons of first melting and scrap, the author ventures to indicate certain principles and methods by which the arrangement of such mixtures should be governed. But, first, a word against that method which may be described as mixing or grading on the silicon basis. When, a generation ago, the influence of silicon on the iron-carbide system in cast iron was first discovered, it was clear that a most important scientific discovery in connection with the properties of iron had been made. It at once became apparent that the founder had been placed in possession of a secret by which he could much more readily control the hardness and softness of his castings than by any method previously known. The result of this was that founders at once chose silicon as a sole basis for adjusting their mixtures, and regarded it at once as *the* governing element; and this consideration of silicon has persisted almost universally in foundries, and, in the opinion of the author, has brought the trade of ironfounding in its connection with high-grade mechanical construction almost to the verge of ruin. Silicon is certainly one of the governing elements in cast iron, but by no means the only one, and with the knowledge that exists to-day regarding the influence of the other elements, the effects of different treatment and different temperatures, the infinitely extended understanding of the forms in which carbon may be precipitated in iron, etc., it will be granted that the arrangement of iron mixtures on a silicon basis is absolutely unscientific.

By this method many matters of equal importance are overlooked. Surely an ironfounder, called upon to make castings against a difficult specification would do better to review the effects of the whole of the foreign elements in his iron, to take into consideration how those elements will affect and be affected by his melting, how they interact, and how their presence or absence in certain quantities will govern the condition and behaviour of his metal when it is tapped and poured. The most fatal mistake that the ordinarily equipped founder can make when called upon to turn out castings of high mechanical quality is to mix high- and low-silicon irons.

The principal elements in cast iron are silicon and carbon, and it will be found that the melting point and specific weight of pig-iron will be governed chiefly by these. It may almost, then, be laid down as an axiom that to get a really fine casting, and get it regularly, we must take for the mixture nothing but irons reasonably alike as regards their silicon and carbon contents. We shall, as nearly as possible, in all our irons fix the silicon and carbon at the figure we wish them to stand at in the mixture (and where we want strength and density there will both be very low), and we shall control hardness, which practically means the final condition of the carbon and its quantity, by careful adjustment of sulphur, manganese, and phosphorus. The second requirement is that we must be guided in the arrangement of the mixture, not only by the theoretical effect of certain percentages of chemical elements on the finished casting, but also by the combined effects of those elements on the physical phenomena of melting and cooling. It is in the discovery of the correct balance between these two factors that the whole problem of ironfounding lies. Supposing we pursue the chemical theory alone as applied to cold cast iron, we shall be tempted to take the purest possible pigs, especially as regards sulphur and phosphorus, so that we may get a casting as nearly approximating steel in homogeneity as possible. This is no doubt an attractive idea, but unfortunately we find that it is not easy to carry out in practice, since the metal, when melted by the cupola, is lacking in fluidity, and, through want of heat and life, cannot expel its gases, slags, or oxides before solidification, the result being blown or otherwise defective castings. It is useless, therefore, to persist with what may be termed the "irreducible-minimum" theory of phosphorus and sulphur for ordinary cupola-melted metal.

It is therefore necessary, in order to get a casting free from flaws and having a close and regular molecular structure throughout, to introduce more of those elements into our iron that promote heat and widen the range of fluidity of the metal, and we shall find that the elements most useful in that direction are manganese and phosphorus. Both of these may be raised to an astonishing degree, even where sulphur is already high, without injuring strength, providing always that the melting is properly done and that full advantage is taken in the casting operations of the liveliness and fluidity of the metal yielded, and as long as the graphitic carbon in the casting is really low.

The whole point of this principle is this: that the final specific density of the casting will be the index of its mechanical and physical qualities rather than its chemical analysis, within, of course, reasonable limits, and this specific density is more easily achieved with a hot, fluid and lively metal holding fair quantities of phosphorus, manganese, and sulphur than with an ideal iron almost free from these elements. The question might possibly be asked,

if fluidity is the secret of success, will not a high-silicon mixture give that fluidity? The fluidity of silicious iron is a well-established fact, but the author's own practical experience is that the fluidity of silicon, though very great while it lasts, is narrow in range, and that the solidification of silicious iron is more rapid once a certain amount of heat is lost than the solidification of phosphoric or manganiferous metal. The author does not understand the phenomena governing the fluidity of irons of different chemical composition, but he does know that it is extremely difficult, if not impossible, to get a tight casting of high specific weight with silicious iron, however fluid, and that it is easy to get it with a low-silicon iron fairly high in manganese, sulphur, and phosphorus.

It will now be gathered that in order to get a considerably improved cast iron, certain conditions are necessary:—

(1) The different irons in the mixture must all have a low silicon.

(2) They should if possible all have a low carbon, but in any case the final total carbon figure of the mixture must be low.

(3) The mixture should be rich in manganese and fairly rich in phosphorus.

(4) The sulphur may stand at a higher figure than that generally considered as the limit by the analyst.

The brands of pig-iron which are most conveniently available for the author's use for purposes of practical experiment are naturally those brands belonging to the company with whom he is associated, and these include certain irons which, in different combinations, will give the desired result for different castings. The actual mixture from which the results tabulated were obtained is as follows:—30 per cent. of Frodair pig, 20 per cent of Bearcliffe pig, 25 per cent. of cold blast pig, 25 per cent hard selected grey scrap.

These irons are all smelted in England and the following is a rough description of them:—"Frodair" is a dense iron carrying a low silicon and a very low carbon but melting very hot and fluid by reason of fairly high percentages of phosphorus and manganese. Sulphur about 0.08 per cent. "Bearcliffe" is a tough iron of the true hematite class carrying about 1 per cent of silicon, a moderate carbon, low phosphorus and high manganese. Sulphur about 0.12 per cent. The cold blast used is a coke iron with the typical cold-blast analysis, very low carbon and silicon, medium phosphorus, sulphur and manganese. The scrap iron used for the job was not analysed but taken on trust. It was judged to hold low silicon, medium carbon, high sulphur, medium phosphorus and manganese.

In the mixture 30 per cent. of "Frodair" is taken to make absolutely sure of the heat and fluidity of the metal and as a really low carbon basis for the specification; 20 per cent. of "Bearcliff" will keep phosphorus within safe limits and will help fluidity by reason of its manganese; 25 per cent of cold blast is now added to restore the carbon figure which has been raised somewhat by the "Bearcliffe," to keep sulphur within reasonable limits and to guard against extreme hardness. These last two irons give most of the strength and toughness to the mixture. The scrap is used as an economy and as much of it might have been taken as the carbon and sulphur figure in the specification would have allowed. All the components have about the same silicon.

Let us now discuss the methods by which such a mixture can best be melted and cast. The first essential point is, that the melting be done as rapidly and as hot as possible. The great trouble in many foundries is that the cupola will not melt quickly and falls a good deal behind its scheduled capacity in this respect. All those who are troubled in this way should tackle their whole melting installation from the motor or engine to the cupola spout circumstantially, comprehensively and scientifically. The failure will generally be due to the blast, and not by any means to lack of power or pressure, but probably, on the other hand, to too much of those, the great bulk of which will be represented by inadequate tuyerage and resistance at the furnace and in the pipe connections. The plan the author would suggest to regulate this important matter is quite simple. Calculating at 35,000 ft. of air for each ton of iron melted, reckon what quantity of air per minute the blower or fan should deliver at its outlet in accordance with the scheduled capacity of the cupola, that is to say, the weight of iron it should melt within a given time, then see that you have a blowing machine so devised as to deliver that quantity of air at that velocity which is judged necessary to convey it freely into the furnace, presuming that your pipes, wind box, and tuyeres are so regulated in shape and area as to offer a negligible resistance to the action of the blower. This velocity will vary somewhat with the size of the furnace, *i.e.*, with the distance which the air has to travel after its first obstruction by the charge. The flow of air under pressure is a question very little understood in the foundry, and most foremen would be astonished if they knew what was quantities of air will flow at high velocity through, say 10-in. unobstructed pipes under a very few ounces of pressure. The foreman should fix his pressure gauge on his blast pipe just before it joins the fan casing, and this is the only useful place in which a foundry gauge can be placed. He then gets the indication he wants, *i.e.*, the amount of air his fan is delivering, because a given velocity is the result of a given pressure and the volume is according to the velocity when the area of the pipe is known. The theory then is: Let the blower deliver the right quantity of air at its outlet, make sure that this air passes under all circumstances freely into the cupola. This can only be done by having the total tuyere area two or three times as great as the area of the blower outlet, so that there may be a wide margin for stoppages in front of the tuyeres throughout the heat.

Now, having brought down the mixture white hot it must be got into the mould as nearly as possible at that heat, that is to say, the metal must be poured as hot as ever we can get it. The author does not believe in the dull-metal theory of casting. We could probably all quarrel very much about this question of pouring temperature; metallurgists, experts, chemists, melters, and moulders are always discussing it and disagreeing about it. The author's own experience is, the hotter the casting temperature the better the casting as regards density and strength. There is probably no temperature in iron melted in a cupola which warrants a delay in pouring, and we must not look in this matter to steel-founding for a lesson. Steel is melted and cast at much higher temperatures than those attainable in the iron foundry. Of course, it is understood that the hotter the iron the greater must be the care and the wider the scope of venting, the more resistant and refractory the mould and the more ample and skilful the feeding.

Benefit of Improved Cast Iron.

The industry of iron-founding has suffered both loss and dignity through the continual rejection of cast iron by engineers for all work where specifications demand more than the British Admiralty tests for transverse and tensile strengths. But the potential strength and mechanical qualities of cast iron are much higher than what is demanded by the severest

specification laid down by modern engineers, and there is a big range of castings now lost to cast iron which can be brought back into the iron foundry as soon as the engineer can be convinced that higher specifications can be met. Let us look at this for a moment in a practical way and take the case of cylindrical castings subject to internal pressure. For thin cylinders may be taken the ordinary engineer's formula, *i.e.*, thickness equals diameter multiplied by working pressure, divided by twice the safe working stress of the material. Now if we take 9 tons as the tensile strength of cast iron and a factor of safety of 6 (which factor will be adhered to throughout all cases) we get a divisor in our formula of 3 tons. Mr. Pettigrew in his book on the locomotive (a standard work) reduces this to 5,000 lbs., *i.e.*, under $2\frac{1}{4}$ tons, so he apparently will not trust cast iron even to have a 9-ton tensile strength. However, we stick to our 3 tons, and taking a steam cylinder of 16 in. diameter and a pressure of 150 lbs., we find we require a wall thickness of $\frac{5}{16}$ of an inch. But supposing our cast iron will stand at 15-ton tensile test, we then, by the same formula get a necessary wall thickness of $\frac{3}{16}$ of an inch—a saving of two-fifths in our material. For engine cylinders the thickness against bursting stress is, of course, largely reinforced by extra thickness against piston abrasion; our improved cast iron will have much better wearing qualities as well as much higher tensile strength, and the engineer will soon find he can also considerably cut down his allowance for reboring.

Take a hydraulic cylinder with a diameter of 8 in. and a pressure of 1,500 lbs. per sq. in. For this class of construction where the thickness of the metal will be great in proportion to the bore, we require another formula, since allowance must be made for the diminished stress on the outer layers of the cylinder wall. The author uses a formula kindly worked out after impartial consideration of the whole problem by an engineering friend, Mr. Leslie Sadler of Bradford. With Admiralty cast iron we get a wall thickness of 2.47 in., with our improved cast iron we reduce this to 1.27 in., or practically half. The section would, of course, be less with a good mild steel, but I submit that where an engineer might reject a section of, say $2\frac{3}{4}$ in. in cast iron he might adopt one of, say, $1\frac{1}{2}$ in. in preference to steel.

It is these direct and concrete considerations which lead the author to urge founders to re-adopt the tensile test for cast iron. The transverse test is not a direct indication of the tensile strength. It is at the best only a comparative test and is only of value in that respect in testing similar types of iron. The difficulty of the even grip and pull on the tensile test piece has been overcome in the best laboratories and the tensile test on the round bar is a much more reliable index of the quality of cast iron than the load test on a square bar. The square bar is a bad shape, its angles offending the most rudimentary principles of design in cast iron constructions. And further, and perhaps most important of all, it will be found that a high tensile record will never accompany that kind of hardness which means trouble in machining, so that this test will always keep the founder on absolutely safe ground when his castings get through into the fitting shop.

Perhaps in the foregoing the author has been offering a counsel of perfection. He may be running his head up against a brick wall, but still he ventures to ask why not, instead of wildly competing in the direction of cheapness and of the substitution of soulless mechanism for intelligent handicraft, compete to turn out a better iron to meet the advancing specifications of to-day; an iron reinforced against water-hammer in pipes and valves, against back-lash in gears, against the growth induced by variations of temperature, against the shock of the hammer and the fret of the piston, against the bite of acid and the sweat of heat.

Appendix.

Records of Tensile and Transverse Strengths and Specific Weights of Mixtures of Pig-Iron (First Smeltings) and Scrap Iron.

MIXTURE No. 1.

Specimen No.	Tensile. Tons per sq. inch.	Transverse (Standard bar) Breaking Load. Tons.	Transverse (Standard bar) Deflection Inches.	Specific Weight (Water 1).
1	15.14*	—	—	7.237
2	18.39	—	—	7.230
3	—	—	—	7.240
4	—	—	—	7.225
5	—	—	—	7.227
6	—	—	—	7.215
7	16.26	1.76	0.35	—
8	17.60	1.89	0.38	—
9	15.27	1.90	0.40	—
10	—	1.854	0.4375	—
11	—	1.870	0.4687	—
12	—	1.825	0.4062	—
13	16.34	—	—	—
14	16.83	—	—	—
15	16.60	—	—	—
16	15.86	—	—	—
17	15.53	—	—	—

Mean Tensile Strength of 10 tests—16.40 tons.
„ Transverse „ „ 8 „ — 1.85 „

MIXTURE No. 3.

1	16.10	—	—	7.240
2	14.26	—	—	7.214
3	—	—	—	7.303
4	—	—	—	7.207
5	—	—	—	7.207
6	—	—	—	7.198
7	15.48*	1.24	0.25	—
8	16.76	1.77	0.40	—
9	14.93	1.54	0.32	—
10	16.62	—	—	7.217
11	17.35	—	—	7.206
12	—	—	—	7.250
13	—	—	—	2.221
14	—	—	—	7.244
15	—	—	—	7.212

Mean Tensile Strength of 7 tests 15.943 tons per sq. inch.

NOTES.—Mixture No. 1 consists of Frodair brands of coke hot-blast pig with some cold blast coke iron and with scrap iron.
Mixture No. 3 consists of Frodair brands of coke hot-blast pig only and scrap iron.
All tests made by R. H. H. Stanger, Westminster Testing Laboratories.
* These test pieces revealed flaws when fractured.

British Foundrymen's Association: Sheffield Branch.

On January 17, Mr. R. Mason, of Leicester, delivered a lecture on "Cupola Practice," the subject with which he dealt in his Paper before the last Convention of the Association. Among other matters discussed, the position of the tuyeres was a topic of considerable interest. A double row of tuyeres was advocated by the lecturer, but certain of the foundrymen favoured the single row. On the question of blast pressure, the opinion was expressed that, on the whole, too much air is blown into the cupola. This again was very much debated. Mr. Mason's figures per ton of iron were $1\frac{3}{4}$ cwts. of coke (exclusive of the bed), and not more than 26,000 cubic feet of air. The admirable Paper concluded with some notes on fluxes. According to quality of coke used, the quantity of limestone necessary for fluxing was given as from 38 to 47 lbs. per ton of iron melted.

Mr. Thos. Swinden, B.Met., who has been undertaking the Secretarial duties of this Branch of the Association, is obliged to relinquish them on account of pressure of work in other directions. Accordingly, Mr. R. W. Kemlo, 6, Lees Hall Road, Meersbrook, Sheffield, has consented to act as Secretary.

Making a 12-Ton Flywheel.

By Percy Jones.

There are various methods of moulding heavy flywheels, but the writer will confine his instructions to a method which, from practical experiences, has been proved to give good results. For the method in question the mould will be sectional, being made by means of cores. Fig. 1 shows the plan of an 8 ft 6 in. flywheel with six curved arms. Two core boxes are required, one to form the inside of the mould, and the other to form the outside, or rim. The last-mentioned core box should be made as shown in Fig. 2,

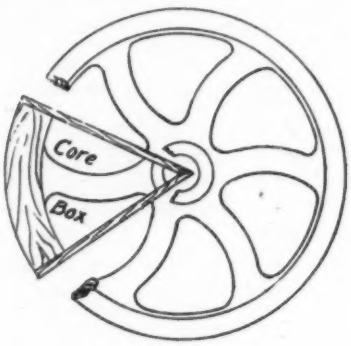


Fig. 1.

which is to form the outer rim of the wheel. Prodded core irons (Fig. 3) are required for making these cores, and these irons are made in open sand. Six of the cores are required to form the outside of the mould. The other core box, which is far more particular, should be made with the arm section of the boss and inside of the rim loose, so that the outside part can be drawn up, leaving the loose parts in position in the core. These loose parts are held in position by screws, excepting the arm, which is slipped into its berth by a taper joint. Lifting plates (Fig. 4) are required, and these plates are made in open sand, with wrought-iron staples cast in them. A number of straight irons to strengthen the core are also required.

Fig. 2.

In making these cores it is first necessary to procure a suitable joint board. Place the core box on it, next clay-wash a lifting plate and insert it in the core box on the joint board. Then place the inner rim and section of the boss in position, and fasten by means of screws, which are taken out from the outside of the core box, and slip the arm into its position. Ram up the core, leaving a layer of ashes under each arm, and using more ashes as the core is being made. Lead the vents up each side of the arm through the top of the core. When it is rammed up the screws which hold the loose parts in position are withdrawn and the outside of the core box drawn up. Next withdraw the inner rim and section of the boss, then the arm, which will have to be drawn out on the curve. Great care must be taken to vent the face of the inner rim with a small vent wire, especially under each arm, as the metal has to run through each arm to fill the rim, and if not thoroughly vented is liable to scab. Six of these cores are required, and are placed in the stove to dry. A cambered centre core, four splitting plates, and a few

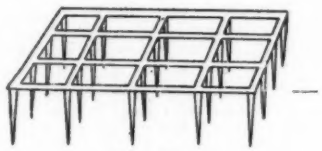


Fig. 3.

dozen small cores to form bar holes in the face of the wheel are also needed. These splitting plates are covered with loam and then tarred and placed in the stove to dry.

While all these cores are drying it is best to make the top box in the following manner:—A hard level bed is made, using straight-edges. This bed must be 10 ft. 6 in. square on the foundry floor. Parting sand is thrown over it, a small wooden wedge is driven into the centre of the bed, and the circle of the boss, inner and outer circles of the rim marked out with a pair of trammels. When this is done it should appear as in Fig. 5. Next place the top box on to this, placing two stout square runner pegs on the boss at each side, and four riser pegs at equal distances round the rim, and proceed to ram the box up, after which place it on four strong legs, one

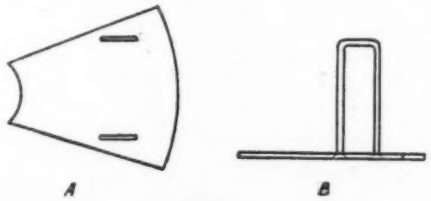


Fig. 4.

at each corner of the box, so that the moulders can get underneath to finish it. Then it is blacked and dried by placing about six small fires under it.

The next job to do is to dig a hole out in the foundry floor 12 ft. 6 in. diameter and the depth of the wheel. Make a firm level bed and proceed just as in making the bed that was made to ram up the top part on, striking out the circles just the same. The job is then ready for the cores to form the inner part of the wheel, and these are lowered down and placed in position according to the circles marked out in the hole that has been dug out. After placing all these cores in position, the joints are made up

with oil and blacking and afterwards dried with hot plates or a blow lamp. Having done this the next thing will be to make the bar-hole core prints, which are made by placing a wooden templet, as shown in Fig. 6, round the outer circle marked, and pressing down a square piece of tube the same diameter. Insert the core and fasten by means of 5-in. sprigs, one at each side.

The moulder will then be ready for the outer cores to form the rim. These are placed in position and the joints made up as before. Having placed all

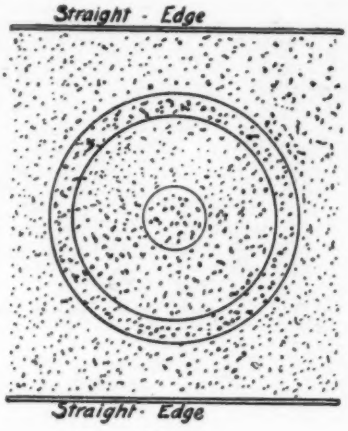


Fig. 5.

the cores round, it will be found that there is an opening of 1 ft. all the way round, which must be rammed up with green sand, and made level with the tops of the cores. The centre core is placed in the boss with two splitting plates, and two splitting plates are placed in the rim. Round each vent of the inner cores is placed a small quantity of whiting for the purpose of taking an impression on the top box, after which a hole through the top box is made where the whiting touches, for taking the vent away.

The top box is now carried over the mould with the crane, and is kept about 2 ft. from the top of the mould. The foreman's job is generally to get on the top box and look down the runners into the boss of the wheel while it is in this position, to get the box in its right place. It is then lowered down and

Fig. 6.

staked at each corner and then lifted off to see if all the cores touch and the splitting plates are not disturbed. These matters being in order, the box is lowered on again, the runners and risers made up, and a piece of hay-band placed in each vent hole in the top box, and made up lightly with sand, leaving the hay-band projecting out at the top. The box is weighted down and the wheel is ready to cast. A good sound clean casting, having no ugly joints on the arms, can be made in this way.

Walsh & Clark, Limited, are making considerable additions to the plant at their Victoria Works, Guiseley, Yorks., to enable them to dispense with the night shift, which has been worked for a considerable time. Extensions to the containing building are also under consideration.

Facing Sand.

The use of facing sand, or that portion of sand which is required to come in direct contact with the face of the pattern, is a highly important matter, in relation to the finished casting, and practical experience in moulding is generally necessary in determining the correct mixtures to use for various classes of work. The mixture is governed by the shape and weight of the castings, and whether any portion of the mould has to offer great resistance to the flow of metal. A facing sand must, therefore, possess the following properties. It must be cohesive, porous, refractory and plastic, and be able to have broken parts of the moulds repaired, with a minimum amount of finishing by the moulder.

It is often necessary to use two different mixings of facing sand to the same mould, as in some cases, according to the shape of the mould, separate portions require special treatment. In intricate portions of the mould a strong, tough and plastic sand is essential in order that it may withstand the wash of the metal. On the broad surfaces this sand would cause scabbing, by being insufficiently porous, and the gases formed in the mould would not have a free exit. It, therefore, follows that for the fluid metal to lie quietly on broad surfaces, an open, porous, naturally self-venting sand must be used, so that the gases may quickly escape without injury to the mould. Many waste castings are the result of a wrong selection of facing sands, and many young moulders do not properly appreciate the comparative values of facing sand mixtures in relation to various classes of work.

For moulds which on account of their shape, weight and formation do not generate a large quantity of gases, and require a strong, firm and plastic sand to obtain a good casting with sharp outlines, the following mixture will be found to give good results:—

3 Barrows Yellow Sand 3 „ Red „ 3 „ Black „ 1 part Coal Dust to 15 parts Sand	Milled 10 to 15 minutes.

The latter may be increased to suit the work. This sand allows the withdrawal of patterns with a minimum of breakages, and when breakages occur they are easily repaired by the moulder, on account of its plasticity. Being of a strong and close texture it must be well vented to obtain the best results. If necessary this mixture will allow skin drying.

As a mixture suitable for general jobbing and when a moderately porous sand is required, the following gives good results:—4 barrows red sand; 1 barrow road sand; 42 lbs. coal dust.

An alternative mixture, which is more open, is as follows:—3 barrows red sand; 1 barrow road sand; 42 lbs. coal dust; 1 riddle of horse dung.

For small, light castings a suitable mixture is:—1½ barrows Mansfield sand; 1 barrow red sand; ½ barrow yellow sand; 20 lbs. coal dust.

For fine wheels the following gives good results:—1 barrow sieved Mansfield sand; 1 barrow yellow sand; 1 barrow black sand; 20 lbs. coal dust.

These last four mixings require putting through one of the numerous combined grinding and riddling machines. The coal dust may be altered in all cases to suit the work to be done. In various shops and districts, different mixings of sand are used, varying according to the individual judgment of the moulder or foreman, but the foregoing will give young moulders an insight in the general methods adopted in the mixing of facing sands.

Fumes in Brass Castings.

The desirability of properly dealing with the fumes from brass casting processes, so that they do not injuriously affect the workmen, does not need to be impressed upon brassfounders, for the matter has been brought well before their notice in the course of the last year or two in connection with the Brass Casting Regulations issued by the Home Office. But considerable interest attaches to any method of successfully

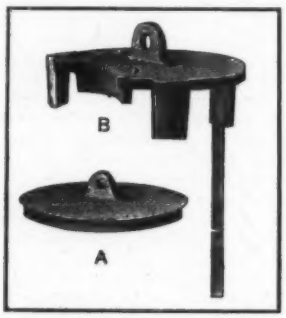


FIG. 1.—PULLING AND POURING COVERS.

dealing with these fumes. Herewith is illustrated the method adopted by Messrs. William Ross & Sons, brassfounders, 27, Thistle Street, S.S., Glasgow.

The apparatus consists of a plain pulling cover (A, Fig. 1); a pouring cover B, and a sheet-iron hood with uptake, which may be connected with the nearest convenient flue or chimney to carry off the fumes when skimming, and which may be made locally to suit the requirements of the user. By the use of this simple apparatus, it is claimed, the escape of the zinc oxide fumes from the crucible is reduced by from 80 to 90 per cent. No appreciable escape of fumes is allowed, except in the act of pouring, when a greatly reduced puff unavoidably rises from the exposed jet of

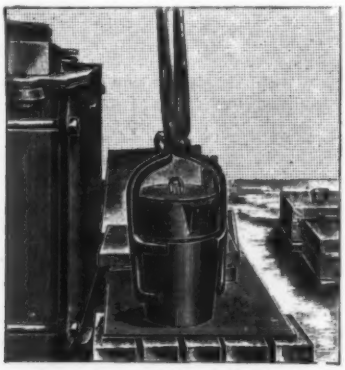


FIG. 2.—CRUCIBLE PULLED FROM FURNACE, WITH PLAIN COVER ON.

molten metal. This escape practically ceases when the crucible is placed upright for carrying. As a result, the atmosphere of the foundry is never impregnated with fumes beyond the capacity of the simplest means of ventilation, either fan or natural draught sufficing to clear the air in a few minutes.

The method of operating with the apparatus is as follows:—As quickly as possible after opening the furnace, and before pulling out the crucible, the plain cover A, is dropped on the latter, and kept on until the crucible is set under the skimming hood, as shown

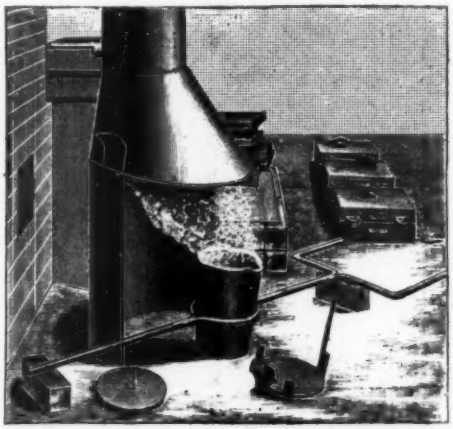


FIG. 3.—CRUCIBLE UNDER SKIMMING HOOD.

in Fig. 3. The plain cover is then removed and the metal skimmed, the fumes being carried off by the hood and uptake to the flue. After skimming, the pouring cover B is placed on, the crucible being still under the hood. The flexible strip attached to the cover should be caught by the ring of the carrier or tongs to keep the cover in position, as shown in Fig. 4. Pouring is then proceeded with in the usual way, and the crucible is afterwards returned underneath the hood to cool before the pouring cover is removed. The smaller crucibles may be poured with pulling tongs in the usual way. Fig. 2 shows the

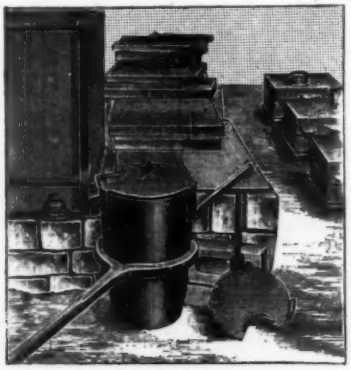


FIG. 4.—CRUCIBLE WITH POURING CURVE IN POSITION.

crucible with the plain cover on, just pulled from the furnace, and Fig. 3 shows the crucible under the skimming hood after the plain cover has been removed, and the metal skimmed. Fig. 4 shows the crucible with the pouring cover on, ready for pouring.

The operation is simple and imposes no extra labour on the men in either carrying or pouring. No restrictions or alterations are necessary in the usual working arrangements of the foundry, and the moulds may be placed wherever is found most convenient for pouring, as there are no attachments to limit free movement. Practically no fumes escape from the crucible when being carried with the pouring cover on, and a greatly reduced quantity escapes when pouring.

The health of the men is greatly benefitted, and their co-operation in working the system satisfactorily is thus secured. The considerable deposit of oxide of zinc, which is found on the crucible covers and inside the skimming hood and uptake, explains the absence of the usual shower of white floating particles from the foundry atmosphere after skimming and pouring. Messrs. Ross & Sons, having proved the utility of the apparatus in their own foundry, have placed it on the market for brassfounders in general.

The Use of Gas in Metal Melting.

In his Presidential address recently, before the London and Southern District Junior Gas Association, Mr. L. F. Tooth devoted considerable space to the subject of the application of gas to the melting of metals, based upon experiments he had undertaken. In the course of his remarks he said:—

In furnaces for metal melting, better results are obtained by entering the burner on the side, at a tangent. The outlet of the flue should be placed about one-sixth of the circumference at the top of the furnace, past the burner entrance, the suction at that point assisting the flame to complete its cycle. When very high temperatures are required, it is advisable to use firebricks of the most refractory nature; also, cupola furnaces should be lined with ganister or magnite, as this not only prevents the surface of the bricks running into a molten state, but gathers the heat more readily. The outer wall of the furnace should be packed with 3 to 4 in. of slag wool, and should be sheet-iron bound.

Metal Melting by Gas and Coke.

The figures for coke are obtained from brass-founders and manufacturers in various parts of the country, who have in use the ordinary draft pit furnace. Those for gas are obtained from actual working conditions at the works of the Commercial Gas Company, where we have a small foundry, making our own castings, not only for gas fittings, but for many other purposes. These are not laboratory figures, but actual commercial results. The table below shows that gas has the advantage from beginning to end.

Comparative Results in Brassfoundry.

	Coke Fired.	Gas Fired.
Size of pots	60 lbs.	60 lbs.
No. of charges per day per furnace (9 hours)	5	9
Weight of metal melted per day	300 lbs.	540 lbs.
Time of first heat	1½-2 hours	1 hour
Time of subsequent heats (average)	¾-1 hour	½ hour
Fuel used per day	2½ cwt.	1,780 cubic feet
Price of fuel (gas includes cost of compression)	11d. per cwt.	1s. 11d. per thousand c.f.
Total cost of fuel	2s. 3½d.	3s. 5d.
Cost of labour for fireman ...	1s.	nil
Cost of metal melted	1s. 2.6d. per cwt.	8.4d. per cwt.
Average life of pots (charges)	30	30
Cost of repairs (twelve months)	£2-£3	£1 10s.

The number of charges by coke are less, owing to the continual banking up of the furnace, and I have taken the maximum output per day by this system. The weight of metal melted per furnace entails, in the case of gas, less capital cost. It will be seen that first heating takes much less time in the case of the gas furnace, which is an important advantage, and prevents moulders having to wait for metal. The space occupied for the storing of fuel presents a further advantage, and, apart from labour, there is a saving in the cost of tools for firing.

The cost of metal melted needs no remark, beyond this that it can be materially reduced, as it is possible, in a nine hours' day, to turn out eleven melts if desired. The longer life of the pots should also be considered. The price of these being 6s. 9d. each, the average cost per cwt. of metal melted would be 4d. by coke, as compared with 3d. by gas. This shows a further saving of 1d. per cwt. Cost of repairs would naturally be less for gas, no stoking being required.

With a gas cupola furnace a very great drawback in brass foundries is overcome, as in the event of moulds not being ready (which is a common thing), the metal can be kept on the melt, without wasting and burning away, by reducing the pressure only. In the ordinary coke furnace this is generally gauged by removing the cover, which is also the method of keeping constant temperature.

The more modern coke-tilting furnaces deal with larger quantities of metal, but even here the melting cost is in the same ratio in favour of gas.

The appended table, showing the various metals that can be melted by gas, may prove of interest. Each individual metal was placed in the furnace when at the temperature of the respective melting points. The cost of fuel per cwt. of metal melted with charges in excess of the weights stated in the table can be reduced by upwards of 33 per cent. The pressure for reducing lead and white-metal rapidly is 10 in. mercury. When desired to retain in a molten state for use, pressure should be reduced to 3 in. mercury.

Pyrometer Tests. Ten-minute Readings; Four Hours' Duration. Gas Pressure, 10 inches Mercury.

Material.	Weight of Charge.	Time.	Cubic Feet of Gas per lb.	Cost per Cwt.	Melting Point.	Required Temperature of Furnace.	Pressure in Inches Mercury
	lbs.	Mins.		d.	Degree Cent	Degree Cent.	
Lead ...	100	4	0 28	0.7	326	500	10
White-metal	60	5	0.5	1.2	420	650	10
Aluminium	63	30	2.8	7.1	628	800	12
Brass ...	60	28	2.8	7.1	900	1,340	14
Gunmetal	60	34	3.2	8.2	1,000	1,400	14
Copper ...	60	40	3.7	9.5	1,054	1,420	14
Cast iron	56	59	6.6	16.9	1,075	1,450	14
Nickel ...	40	150	30.7	6.7	1,550	1,750	24

Aluminium is a metal with a specific gravity of 2.56, being one-third that of brass. The cost per cwt. is not in the same proportion, owing to the increased capacity required for the same weight of metal. If you refer back to lead, this is the reverse, the specific gravity being 11.37. Brass, gunmetal and copper being composed of similar metals, the cost of reducing is in ratio to the melting point. Nickel being a metal of high melting point (upon which authorities differ), requiring practically the maximum temperature at present obtained in a gas-fired furnace, the reducing cost is considerably in excess of other metals in proportion. Even so, the use of gas is commercial, as there are many difficulties experienced with coke-fired furnaces for this purpose.

The figures given in the table are for nickel of 99.99 per cent. purity. In the event of gas being adopted for melting nickel, this country may reap a benefit, as owing to the difficulties mentioned and the excessive cost of reducing, the whole of rolled nickel is now imported from abroad.

The Institute of Metals.

Annual Meeting in London.

The annual meeting of the Institute of Metals took place at the Institution of Mechanical Engineers, Storey's Gate, Westminster, on Wednesday, January 18th, Sir Gerard Muntz (President) in the chair.

According to the Report of the Council the membership of the Institute had increased from 505 in December, 1909, to 551 at the end of last year. In the record of the work done during the past year it was stated that a Committee had been appointed for the purposes of furthering the study of the cause or causes of corrosion of metals and alloys coming within the purview of the Institute, and at their first meeting, Mr. G. D. Bengough had undertaken to prepare a summary of the literature dealing with the subject. A pathological museum of non-ferrous metals had been established at the offices of the Institute at Caxton House, Westminster, and the formation of a library had been commenced.

The reports and accounts were adopted.

Sir Gerard Muntz was re-elected President, and among the other officers elected or remaining in office are Sir W. H. White (Past-President), Professors H. C. H. Carpenter, W. Gowland, and A. K. Huntington, Mr. W. H. Johnson, Vice-Admiral Sir H. J. Oram and Sir H. A. Wiggin (Vice-Presidents), Professor T. Turner (Treasurer), and G. Shaw Scott (Secretary).

After the Presidential address the reading and discussion of Papers was then proceeded with; abstracts of the Corrosion Committee's Report and the Papers are appended.

On Tuesday, the day previous to the business meeting of the Institute, a visit was paid to the yard of the Thames Iron Works Shipbuilding and Engineering Company, Limited, to inspect the new Dreadnought, H.M.S. "Thunderer," which was launched last week.

The second annual dinner of the Institute was held in London on Tuesday evening, under the chairmanship of Sir Gerard Muntz.

The Autumn Meeting.

The PRESIDENT, in the course of the meeting on Wednesday, announced that the Newcastle-on-Tyne members had invited the Institute to make that city the venue of their autumn meeting. It was also announced that Dr. Beilby, F.R.S., of Glasgow, would deliver the May lecture.

REPORT OF THE CORROSION COMMITTEE.

The report to the Corrosion Committee on "The Present State of our Knowledge of the Corrosion of Non-Ferrous Metals and Alloys, with Suggestions for a Research into the Causes of the Corrosion of Brass Condenser Tubes by Sea Water," is the work of Mr. Guy D. Bengough, M.A., Lecturer on Metallurgy at Liverpool University. It is a general review of our present knowledge of the subject of the corrosion of non-ferrous metals, both in its practical and scientific aspects, and is probably the most comprehensive monograph on the subject that has hitherto been available. Space will not permit of an extended survey of the report, but briefly it may be noted that the author points out several important gaps in our knowledge which, in his opinion, call for immediate attention. The theory of corrosion is considered in some detail, and an attempt is made to lay a broader scientific foundation for the whole subject. Two series of experiments are proposed, which, in the author's opinion, should be taken in hand at once. One series is of an empirical nature, and is intended to test the validity of certain opinions held on the subject by practical men, and especially such opinions as are in dispute between different authorities. The other series of experiments is of a purely scientific nature, and is regarded as a means of elucidating certain causes of corrosion that have hitherto been obscure. The scope of the Report can best be indicated by enumeration of the titles of the six sections into which it is divided. These are as follows:—Section I., Introductory and Historical; Section II., Summaries of the more important Technical Papers; Section III., Synopsis of the Views of the Authors whose Papers are summarised in Section II.; Section IV., Electrolytic Theory of Corrosion; Section V., Restatement of the Problem of Corrosion; Author's Views of the Problems Involved; Section VI., The Question of Acceleration Tests; Suggested Research Scheme.

SOME PRACTICAL EXPERIENCE WITH CORROSION OF METALS.

A most interesting practical Paper dealing with the question of the corrosion of metals on shipboard was that presented by Engineer Rear-Admiral John T. Corner, C.B., entitled "Some Practical Experience with Corrosion of Metals." The author points out that some of the causes of corrosion of metals on shipboard are so obscure and the origin so difficult to trace that satisfactory explanation is seldom forthcoming. Corrosion of a minor character existed in the old wooden warships; but when iron was used for shipbuilding, the conditions were different, and it was soon found that the ships' plates and angles suffered from contact with the copper pipes and bilge water, the "Megaera" being a case in point, where the copper so affected the ship as to necessitate beaching her to prevent her sinking. Trouble from corrosion largely increased about the time of the introduction of the electric light afloat. Suggested causes of corrosion were considered, and the conclusions arrived at that the origin is chemical, induced by galvanic action and kept active by erosion. Also noted that the presence of air and moisture together largely influence the extent of the corrosion, as instanced in the case of propeller blades. Instances are quoted of immunity being afforded by the presence of bare iron. Referring to the various methods tried to obtain protection, the opinion is advanced that the most efficient of these is the free use of iron or steel in perfect metallic contact, and it is suggested that if iron plugs be inserted in the parts of the propeller blades much affected by corrosion, the result might prove beneficial.

A NEW CRITICAL POINT IN COPPER-ZINC ALLOYS. Its Interpretation and Influence on their Properties, with an Appendix on the Nature of Solid Solutions.

This Paper, by Prof. H. C. H. Carpenter, M.A., etc., and Mr. C. A. Edwards, M.Sc., states that a new critical point has been found in those alloys of copper-

zinc which contain the beta constituent. The temperature of this point is 470 degrees C. The physical meaning of this change is that the beta constituent decomposes at 470 degrees C. into the alpha and gamma constituents. It is well known that the gamma constituent is very brittle, and whilst the effect of its presence in the slowly-cooled brasses are not marked in the freshly-prepared alloys, it was thought that this was purely a question of time. Hence the authors expected to find that old specimens of brass would show a deterioration effect. This was clearly indicated in some pieces of brass wire dating from 1854, which were extremely brittle. To show that this brittleness was due to the above-mentioned inversion and the time it was kept, it is only necessary to say that after heating to about 600 degrees C. for a few minutes the wire became quite malleable again. The appendix by Mr. C. A. Edwards deals with the "Nature of Solid Solutions." The conclusions are that a metallic crystalline mass, often described as a solid solution, is an intimate crystalline mixture, and whilst the primary crystals are so small that the mass appears quite homogeneous when viewed under the microscope, they are sufficiently large to retain their identity. The term "solid solution" is not, strictly speaking, applicable to crystalline bodies such as metallic alloys, and should be restricted to super-cooled liquids such as glass.

THE ADHESION OF ELECTRO-DEPOSITED SILVER IN RELATION TO THE NATURE OF THE GERMAN BASIS METAL.

This Paper, by Prof. A. McWilliam, Assoc.R.S.M., and Mr. W. R. Barclay, is of importance to electro-plate and German-silver manufacturers, and gives details of researches undertaken with the view of determining the nature of the adhesion of electro-deposited silver to the German-silver alloys generally used as a basis metal; and whether any differences exist between various grades of alloys as to their suitability for use in the manufacture of electro-plate which may be called upon to withstand rough usage. The increasing use of electro-plated spoons and forks has resulted in these articles being required to endure much severer treatment than was formerly the case, and it has been found by experience that trouble occasionally arises owing to the silver coating becoming broken or fractured, and subsequently stripping from its base. Particularly is this the case with thick deposits of silver. Experiments have been made with a number of typical samples of German silver, as also with a series of special nickel-silver alloys prepared by the authors themselves, and descriptions of the various tests employed and their results are given in detail. The authors find that under the severest conditions of wear there is a great tendency for thick electro-deposited silver coatings to strip from the alloys of high-nickel contents known as firsts, that the plating adheres most firmly to the lowest grades known as fifths, but as these are generally too soft or too weak for the special purpose, the best medium is found somewhere in the region of the alloys known as thirds. Attention is drawn to the fact that the metallurgist has often to reconsider the properties of his materials and his methods of manufacture as new conditions arise requiring his products to withstand a different type of usage.

SOME TESTS ON WHITE ANTI-FRICTION BEARING METALS.

The authors of this Paper, Messrs. C. Alfred M. Smith, M.Sc. (Assistant Professor of Engineering, East London College, University of London), and H. J. Humphries, M.Inst.M.M. (Metallurgist to the Atlas Metal and Alloy Company, Limited), refer at the outset to one of the difficulties connected with the question of publishing the results of these experiments. The directors of the manufacturing company whose metals are chiefly the subject of the Paper were naturally not prepared to disclose to the public the precise formulæ of the alloys under test. It was decided, therefore, to select as a standard of comparison a published formula of undoubted value. The standard metal of the Italian State Railways, referred to under the mark F.D.S. (Ferrovie Della Stato)—for which the manufacturers in question have executed some large contracts—was selected as such standard of comparison. The reason was that it closely approximates to the formula selected by Charpy for that alloy which has little brittleness with high resistance to compression. The formulæ are as follows:—

	Per cent.	Per cent.	Per cent.
F.D.S. ...	tin 83.0	antimony 11.0	copper 6.0
Charpy...	,, 83.33	,, 11.11	,, 5.55

Four other alloys were selected for comparison with the standard. The chief difference between the standard and the four comparative alloys is that, in a gradually extending degree, the 83 per cent. of tin in the former is replaced by lead in the latter. There is, of course, such re-arrangement of the antimony and copper proportions as experience has shown to be desirable where lead enters into the composition. It may be said, however, that even in the alloy poorest in tin a very substantial percentage of that metal is present, and this Paper does not profess to deal with lead basis alloys at all, although such alloys undoubtedly serve a useful purpose in engineering practice. It will be seen from the results given, that in some of the tests the most expensive alloy—that containing no lead—does not show the best results.

So far as could be ascertained, there seems to be no standard mechanical tests for bearing metals, and the chief object of the present Paper is to promote a discussion which will give some indication of the tests which practical men think are most suitable.

Steel users insist upon certain physical tests in addition to chemical analysis, and it would seem to be advantageous for some standard to be set for similar tests for the guidance of white-metal users.

The most obvious test for a bearing metal is one which reproduces as nearly as is possible the actual conditions under which the material is used. Unfortunately, such conditions are very difficult to reproduce in a number of tests so as to give comparative results, and it was therefore considered better to obtain the views of the members of the Institute on this and other matters before undertaking a long and possibly expensive series of tests.

It is essential for commercial tests to be able to repeat easily the condition under which the experiments are made. Among the variables which obtain with friction tests—other than the materials tested—are the quantity and quality of the lubricant, the temperature, and the "bedding in" of the bearing. Moreover, it is considered that, although it may be possible to overcome some of these difficulties in a college laboratory, such tests are not suitable for commercial purposes. They are obviously more expensive than static tests. It must also be stated that there is at present no apparatus at the disposal of the authors for making these tests. It is, however, probable that, should the members of this Institute think them necessary, arrangements could be made for the subject to be fully investigated. It should be remembered, moreover, that the primary object of this Paper is to obtain a discussion on commercial methods of testing bearing metals.

It is obviously essential that a bearing metal should

be strong and tough in order to withstand high pressures. There are also the questions of its durability, ease in fixing and replacing, corrodibility, and cost.

The results of the various tests are given below, and great care was taken to ensure that all specimens were tested under almost exactly similar conditions. Thus the time of loading, the method of gripping specimen, etc., were carefully considered. Ingots were supplied bearing five different marks:—F.D.S., A.M.A., T.X.S, A1, T,X,S,, M.B. All the ingots were found on being worked to be quite sound and free from blowholes.

Tests Carried Out.—The materials were tested:—(*a*) In tension to destruction; (*b*) in compression; (*c*) for hardness; (*d*) in bending to destruction; (*e*) by impact; (*f*) micrographically. The following is a summary of results:—

Material.	Compression.		Tension. Stress in tons per sq. in. at fracture.	Brinell's hardness number Load 500 kgs	Bending.		Impact Energy used per sq. in. Foot-lbs.
	Stress. Tons per sq. in.	Strain. Per cent			Stress. Tons per sq in.	Distortion. in.	
F.D.S. ...	5.978	1.45	5.00	30 8	8.60	0.33	2.99
A.M.A. ...	5.943	0 66	5.86	30 1	8.48	0 29	3.48
T.X.S., A.1	5.878	3.12	5.64	23 3	7.93	0.50	2.42
T.X S. ...	5.982	4.07	5 32	20 5	7.13	0.57	1 89
M.B. ...	5.839	30.63	4.34	17 2	6.34	0.68	1.94

A study of the above table reveals the fact that there seems to be very little difference between the metals F.D.S. and A.M.A., so far as the physical characteristics are concerned. In some of the tests the A.M.A. metal is superior to F.D.S. It was practically impossible to measure the breaking loads of these metals in the compression tests. The elongations are not recorded for the tension tests, as they were too small to be measured accurately with ordinary workshop appliances.

There was very much less distortion when the compression load remained on the metals for a short interval of time, say one minute. All of these metals would carry considerably higher loads for a few seconds. The fifteen minutes' compression test may be considered as a severe trial of the metals.

The material M.B was the only one which was very much distorted after carrying for fifteen minutes a load of 6 tons. This is explained by the fact of it being the alloy containing the highest percentage of lead. It is really on the border line between tin basis alloys and lead basis alloys. It may here be remarked, however, that even the M.B. satisfactorily withstood loads and stresses far in excess of any that would be used by designers of bearings for practical work; while the other alloys showed a very large margin of safety.

The above results show the physical characteristics of the various materials, and it is for the members to discuss their relative importance. It is very much less difficult to make such tests than to run friction tests, and it would appear, therefore, to be an advantage if some definite decision could be come to concerning the most suitable physical tests for such metals.

The results of the microscopic examination show distinctly that the SnSb crystals are not materially affected under very considerable pressure. The $SnCu_3$ crystals, although materially deflected by the flow, evidently must exert a considerable influence in strengthening the structure.

Tendencies in the Foundry Industry.

Writing in the "Iron Age" on the subject of "Recent Tendencies in the Foundry Industry," Dr. R. Moldenke, Secretary of the American Foundrymen's Association, remarks that two things which broad-minded men of affairs would like to see realised—and modern tendencies in the foundry industry are working that way—are the payment of a premium for brains in the works and the elimination of that killing labour which is the bane of the moulder's existence. The moulding machine, he considers, is not developed sufficiently to fit with these two desiderata. Subsidiary apparatus must be added and a higher grade of men employed to bring about ideal conditions. He draws attention to the heavy labour the man in charge of moulding machines has still to perform. The handling of the sand, the tucking-in that may be necessary, the lifting of the moulds—all mean the continued bending of the back and exerting the muscles of that region to an extent which leaves exhausted men at quitting time. All this should be accomplished by machinery, and the moulder should only look after the fine points of adjustment and finish, and thus bring the proprietor the full return for his invested capital. It is high time that the myth of a moulder having to pour his own work be done away with, for a specially trained pouring gang can do better.

Continuing, the writer says, "A still worse feature is the lot of the labourer attached to the moulding machine outfit. Who has not seen this individual carry the prolific output of a good machine with an easy pattern pretty nearly over a quarter of an acre of ground? With heavy moulds, that is manskilling, and the moulding-machine fraternity should bend its energies in the direction of means, pneumatic or otherwise, to handle the moulds as far as completed—whether by sliding along or conveying—without lifting them in any way until they are dumped.

"The development of the moulding machine along the lines of the jarring machine, with the big castings that can now be made with this, will go a great way toward solving the problem of the moulder. With sand-conveying and facilities for handling the moulds rapidly, the tonnage of a foundry can be greatly increased. Even in the smaller establishments, notably jobbing shops with some special line of machinery castings as part of the daily output, the jarring machine is being installed, and large castings thus cared for rapidly and with comparatively few men. Space is economised, and the specially good men can be put at other moulding work.

"The great advantage of moulding machinery as adapted to large work is that it becomes an easy matter to so adapt continuous pouring in the jobbing shop that moulding proper may continue all day long. Only those who know the capabilities of the ordinary cupola for intermittent melting can see this readily; but it is actually an easy matter to begin pouring at 7 a.m., and, stopping for a few hours at a time all day long, to have molten iron available almost on tap for each big mould as completed."

In conclusion, the writer states that the question of the iron mould is becoming an acute one. Gradually foundrymen are learning to appreciate the principles underlying the exchange of metal for sand as the container for molten iron, and the future will see the introduction of this new method of casting developed quite rapidly.

Business Methods for the Ironfounder.

Order Progress Records.

By Percival P. Richards, A.C.A.

One of the most fruitful sources of increased business in foundry and engineering work, is a reputation for prompt delivery and the ability to complete breakdown or "rush" orders with expedition. When a job is up for competition, the firm which can promise the earliest delivery and keep their promise is usually the one which obtains the business.

It is of little use attempting to locate the cause of delay when the delivery date arrives and then explaining and apologising to a customer. Delays should be detected on the day on which they occur and remedied at once. In order to do this with certainty a system is necessary which will reveal to the management every day the exact location of each piece of work on hand and the state of completion—or incompletion—in which it is. The knowledge of the existence of such a system will act as a spur to slow or lazy employés and the openings for excuses and the covering up of bad work or defective castings will be much reduced. Any tendency to fall behind scheduled

Works Manager.

RULING NO. 1.

PARTICULARS.	ACKNOWLEDGMENT OF ORDER.
Order No. ..... Delivery Date.....	Telegrams ..... Telephone..... Sheffield, January 1st, 1910.
DETAILS OF ORDER.	Messrs..... We beg to acknowledge with thanks your esteemed order of the .....inst., as per annexed particulars. Yours faithfully, Please quote Order number in all communications respecting these goods.

RULING NO. 2.

Order No..... Delivery Date.....	NAME OF FIRM.
DETAILS OF ORDER.	PRICE DELIVERED £.
	NET WEIGHT REQUIRED. T. C. Q. LBS.
	PARTICULARS OF PATTERN.
	PARTICULARS OF DRAWING.

PROGRESS OF WORK.

DRAWING OFFICE.		COREMAKERS.		CLEANERS.		INSPECTION.	
Received.	Sent out.	Received.	Sent out.	Received.	Sent out.	Received.	Sent out.
PATTERN SHOP.		**MOULDERS.**		**MACHINE SHOP.**		**DISPATCH.**	
Received.	Sent out.	Received.	Sent out.	Received.	Sent out.	Received.	Sent out.

Works Order Form.

RULING NO. 3.

Order No..... Delivery Date.....

DETAILS OF ORDER.

NET WEIGHT REQUIRED. T. C. Q. LBS.

PARTICULARS OF PATTERN.

SPECIAL INSTRUCTIONS.

PROGRESS OF WORK.

DRAWING OFFICE.		PATTERN SHOP.	
Received.	Sent out.	Received.	Sent out.
Signed		Signed	
COREMAKERS.		MOULDERS.	
Received.	Sent out.	Received.	Sent out.
Signed		Signed	
CLEANERS.		MACHINE SHOP.	
Received.	Sent out.	Received	Sent out.
Signed		Signed	
INSPECTION.		DISPATCH.	
Received.	Sent out.	Received.	Sent out.
Signed		Signed	

RULING NO. 4.

Order No.	DRAWING OFFICE.	
	Received.	Sent out.
Order No.	PATTERN SHOP.	
	Received.	Sent out.
Order No.	COREMAKERS.	
	Received.	Sent out.
Order No.	MOULDERS.	
	Received.	Sent out.
Order No.	CLEANERS.	
	Received.	Sent out.
Order No.	MACHINE SHOP.	
	Received.	Sent out.
Order No.	INSPECTION.	
	Received.	Sent out.
Order No.	DISPATCH.	
	Received.	Sent out.

time can also be checked. At the same time, a system tending to greatly increase clerical labour should be avoided. The following system, which must be adapted to the special requirements of any firm, has stood the test of practical working, and can be recommended as efficient.

Each order when received should be classified into one of the following divisions:—

(1) "Rush" or urgent orders on which the date of delivery is imperative.

(2) Ordinary orders with fixed delivery date.

(3) Ordinary orders on which delivery within a reasonable time is all that is necessary.

Acknowledgment of receipt of order is made on a special form, as shown by Ruling I., the body being filled in on the typewriter. The left-hand side of Forms No. 2 and 3 are filled in at the same time by means of carbon sheets inserted between the forms on the typewriter.

The top form of the series, which is identical with the acknowledgment, is retained for reference and filing, and takes the place of an order record book, the forms being numbered and filed consecutively. The acknowledgment is posted to the customer in place of the usual letter of acknowledgment.

The second form, as per Ruling No 2, goes to the works manager, the particulars on the right-hand side being filled in separately either by hand or typewriter. From this form the work's manager will issue instructions to the drawing-office for the preparation of the necessary drawings.

The next form, as per Ruling 3, is for use throughout the foundry, and is issued in place of the usual works order. Attached to this form by means of perforations, is an additional form as Ruling No. 4. If preferred it may be treated as a separate slip attached by means of a fastener or clip.

Forms 3 and 4 are passed on from one department to another, as the work progresses. When the order

form is received in a department the date of receipt is noted on the slip referring to the particular shop, and when the work of that shop on the job is completed, the job and the forms are sent on to the next shop, the date of so sending being again recorded on Form 4—one slip of which is torn off and sent into the manager's office. Thus when job No. 629 passes out of the core-maker's hands the foreman sends his slip to the works manager's office completed as follows: —

Order No. 629.	Moulders.	
	Received January 1/11.	Sent out January 10/11.

These slips as received in the work's manager's office are pasted on to the back of the order record, form No. 2, and the dates entered on the space there provided.

When an urgent or "rush" order is received, after the forms are made out, a gummed slip coloured red and marked "urgent" should be pasted on each of the forms Nos. 2 and 3, so that there may be no doubt as to the urgency of the job, the general work's instructions being that any order so marked is to take precedence over all other work on hand. In order to minimise the chances of delay on issuing instructions for an "urgent" order, a special form should be immediately sent to the foreman of each department affected. This form should be on red paper as follows: —

URGENCY NOTIFICATION.

Order No..... Date.....

To Foreman.....

Please note that the above order must take precedence of all other work, subject only to special instructions from the Works Manager. All necessary preparations to be made before the job reaches your department. Probable time of receipt by you.....

Details of Order.

Signed.....

Each foreman upon receipt of this form must examine the details, and then proceed to make any necessary preparations and obtain all patterns, tools or stores required so that there may be no delay in proceeding with the work.

Orders for which there is a fixed date of delivery will be distinguishable from those on which no date is given by the presence or otherwise of the delivery date on the work's order form (see Form 2).

Each foreman should be provided with a small box divided into three compartments marked special, dated, undated, respectively, in which he may sort and keep the work's orders on hand, and when a job is passed on to the next department Form No. 3 is sent with it after the times of receipt and despatch are noted thereon, the proper slip, as per Ruling 4, being filled in, detached and sent in to the work's manager's office.

The work's manager should also be provided with a box as above, in which to keep his copies of the orders issued. This box will contain only orders on hand. When a job is completed and delivered, all forms in connection with it should be returned to the office, where they would be fastened together and filed away for future reference.

So that quick reference may be made to any order on hand a cross index record should be kept in card index form, with a separate card for each customer as follows: —

Customer's Name.

Date.	Order No.	Rush, Dated or undated.	Short Details.

By reference to this index the order number and short particulars under any customers name can be ascertained, and the actual order form turned up without any loss of time.

Each morning the work's manager, or his assistant, should go through the box of orders on hand to ascertain the state of progress of each job, and where there appears to be any delay, or if further particulars are desired from any department, enquiries can be made by telephone, or an order progress report form may be sent out giving the order number and a short statement of particulars required, and a request for an explanation of the delay, the exact location of each job being known from the information on Form 3. The progress report form is as follows: —

URGENT.

Progress Report. Works Manager's Office.

To .....

Please report *immediately* as to causes of delay of Order No.....

Length of Delay.	Report.
	Foreman's Signature .....

When this information is obtained, the manager being in possession of full details, can issue any supplementary instructions required, and if necessary reprimand delinquent workers. There will thus be no chance of orders being held up or delayed without the matter being at once brought to the manager's notice, and the cause of delay can be remedied without loss of time, each order being followed from the time it leaves the office until it is finished. Enquiries by customers as to progress and probable dates of delivery can be answered quickly without any search being made in the works, and promises can be made which will be kept, thus obviating any chance of annoying customers by breaking faith with them.

Delays are frequently caused by goods not being in store when required for use. They can be prevented by instructing the store-keeper to inspect the record of orders on hand each morning, and to note down particulars of stores likely to be required for their completion. If he finds that certain articles required are not in stock, he should at once issue a requisition to the office asking for them to be ordered. In the case of "urgent" orders, details of stores required should be sent direct to the store-keeper, so that he

may have them ready and order any necessary ones by telephone or telegram.

This system, subject to any modifications necessary to meet special requirements will check any tendency to "slacking" in the works, and enable the management to ensure punctuality in delivery.

In order to facilitate the office work, it is often convenient for the despatcher to be provided with special forms, one of which he will fill up and return to the office in respect of each consignment sent off, so the castings may be invoiced the same night as they are sent off. The following form may be used:—

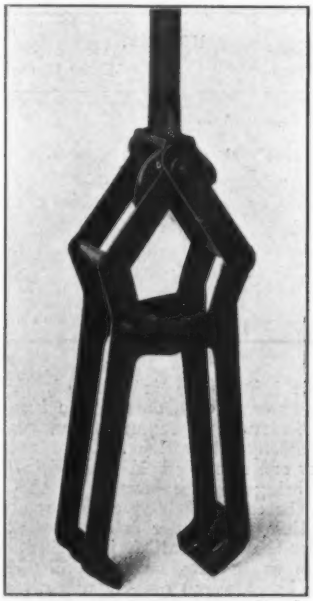
No.	Consignment Report.
Date.	Details of Castings sent.
Order No.	
Consigned to	
Weight.	
Sent per Route	

This form can then be used also for checking the accounts of railways and carriers.

Foundry Plant and Equipment.

Automatic Flask Bar Tucker.

At a recent meeting of the Philadelphia Foundrymen's Association, Mr. James Whitehead, of the Abram Cox Stove Company, Philadelphia, Pa., U.S.A., described an automatic flask bar tucker which he has designed to lessen the work of the moulder in tucking the sand underneath and around the cross bars of the moulds used in floor work, the old methods being extremely hard on the moulders fingers, especially if the bars are of iron. A practical demonstration of the working of the tool was given, and for this purpose a



AUTOMATIC FLASK BAR TUCKER.

large flask, with a barred hinged cope, was used, and the sand tucked under the bars with the tool, showing the ease with which this is accomplished. Repeated operations showed the satisfactory result of the method. In discussion it was brought out that nailed or partly burnt bars interfered in no way with the operation of the device, and that it had had a long trial, particularly in stove plate work, and in a number of other classes of work where barred flasks have been used.

The apparatus, which is shown in the accompanying illustration, opens and closes itself automatically, and while not heavy, possesses sufficient strength to withstand ordinary foundry rough treatment without getting out of order. The wooden handle is 3 ft. 6 in. long and fits into a cast iron socket having a gauge to keep it in an upright position. Steel legs are attached to the socket and at their lower ends are the small castings which do the work of tucking or tamping the sand under the flask bars. The length of the tool from the socket to the ends of these small castings is 16 in., which makes the total over all height 4 ft. 10 in.

Openings in the tamping ends are provided through which the sand can pass, thus eliminating all danger of a false parting being caused by the sand being pressed too firmly by the tool. A small casting with pins is attached to the handle socket and prevents the jaws opening too far. The jaws open automatically when the tool is raised, and when pressure is exerted on the handle the legs come together by a toggle lever action and force the sand beneath the bar. In operation the tool permits the moulder to stand erect at his work and walk over the bars if desired, thus effecting a considerable saving in time and also performing the work better than was possible by the old methods.

Arrangements have been made with the J. W. Paxson Company, Philadelphia, Pa., to manufacture the tool and place it on the market as soon as the patents are granted.

Universal Wood Grinding Machine

The accompanying illustration, Fig. 1, shows a wood grinding machine which will be very interesting to all our readers. Fig. 2 shows samples of work, of all manner of shapes, which have been finished on the machine, from which it will be seen that the name given to the tool is no misnomer. This grinding machine is primarily designed to meet the needs of pattern-makers. The makers claim that it is equally suitable for wood and metals such as brass, bronze, aluminium, etc., also for vulcanite, papier maché, etc. It is useful in all places where curves have to be treated.

The machine simply consists of two drums of different diameters mounted, with their axes, vertical on an entirely enclosed bed of box section. The diameters of these drums are 10 in. and 2¼ in. respectively. The larger drum is driven by means of a belt through a pulley on its spindle immediately under the bed, and should run at 1,000 r.p.m. Over these drums runs a cloth band covered with sand, emery or other suitable abrasive material, according to the work in hand. Then two tables are provided, one at each end of the bed, and arranged so as to embrace half the circum-

ference of the drums. These can be tilted to any angle up to 45 degrees, thus enabling bevelled edges to be easily produced. A third table, of suitable size, and also arranged to tilt, is provided as shown. This take the weight. The small drum, which is solid, is turned all over and fitted with ball bearings. All bearings on the machine are specially designed with a view to excluding dust and grit. The machine is

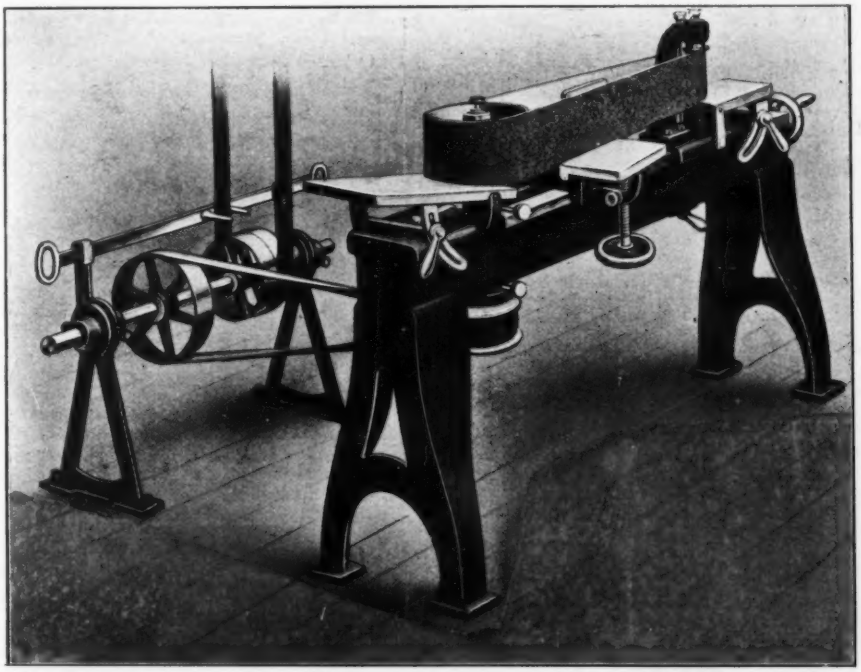


FIG. 1.—UNIVERSAL GRINDING MACHINE FOR WOOD OR METALS.

combination of the vertical sand belt with the large and small size drums and the tilting tables enables the machine to deal with all kinds of curves and irregular shapes, whilst at the same time it is equally suitable for straight pieces.

arranged so that all adjustments required when working can be made without the use of a spanner or other tool.

We are indebted for the description and illustration of this machine to The Judson-Jackson Company, 14,

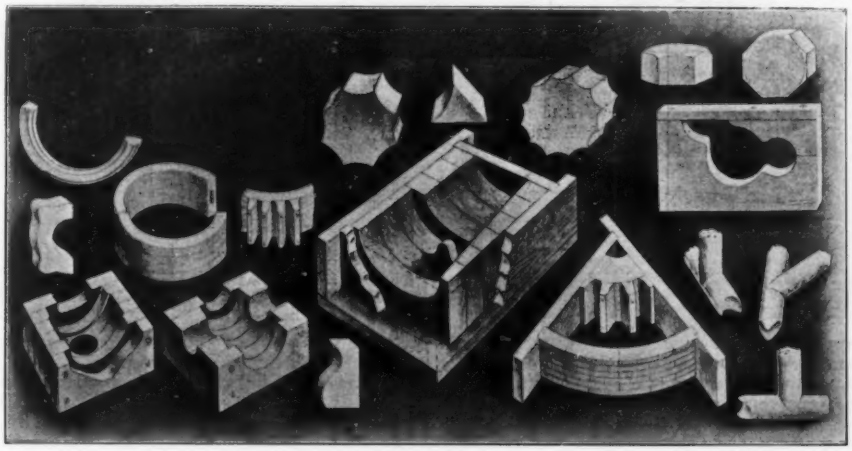


FIG. 2.—EXAMPLES OF WOOD-WORK TREATED ON GRINDING MACHINE.

The large drum is turned all over and accurately balanced on its spindle. The spindle runs in gun-metal bushes, and a ball thrust washer is provided to

Great Smith Street, Westminster, London, S.W., who are the representatives in this country for the machine.

210187A

Blowers for Cupola Work.

In the accompanying illustration, Fig. 1, is shown a steam-driven "Climax" Roots blower and engine combined, suitable for foundry work. For working with high pressures this class of blower has many points to recommend it.

The blower cylinder is of cast iron, strongly ribbed where necessary, planed on meeting flanges, and accurately bored the whole length of the cylinder. The end plates are of cast iron, as also are the revolvers, which are accurately machined all over the outside to the correct radii, faced on ends, and bored to receive the steel shafts, on to which they are secured with sunk keys. The shafts are of Bessemer steel, and the gear wheels are machine-cut from solid blanks. The gear covers are of cast iron made in two halves and form an oil bath for the wheels to run in. The bed plate is also of cast iron.

The bearings are a special feature of these blowers. They consist of a heavy gun-metal sleeve bored to fit the shaft, and having a cone on the outside at each end; three slots are cut in the outside three-part way through the metal, and one, the top one, right through. This arrangement allows all wear to be taken up by simply screwing up the nut behind the cone and forcing it inwards. The engines are of the duplex connecting rod type, each blower shaft being driven by a separate rod; this arrangement gives very steady running and practically eliminates all vibration.

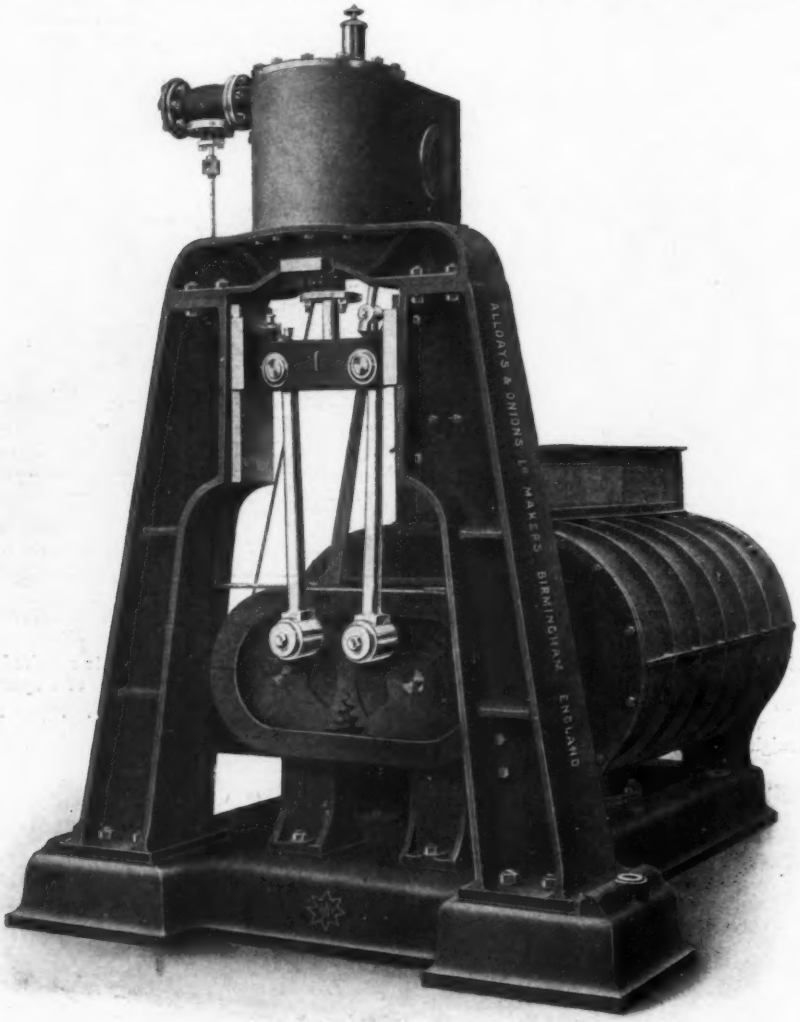


FIG. 1.—STEAM-DRIVEN "CLIMAX" BLOWER AND ENGINE COMBINED.

Fig. 2 shows an electrically driven blower and motor combined, the motor being 80 b.h.p., alternating current. This blower is capable of delivering 19,400 cubic feet of air per minute, and represents a type which is now being largely employed for cupola work. In fact, where electric power is available it is fast displacing steam-driven blowers. The motor and blower shown in Fig. 2 are self-contained, being mounted on a heavy cast-iron bed plate, the motor

driving through reducing gear, consisting of a raw hide or paper pinion on the motor shaft gearing into a machine-cut cast-iron wheel mounted on one of the blower shafts.

The makers of these two blowers are Messrs. Alldays & Onions Pneumatic Engineering Company, Limited, Birmingham.

The "Ajax" Jolting Moulding Machine.

With this pneumatic machine, which is of the combined gravity drop and power press type, the mould is formed about the pattern by jolting and pressing. The actual time required to condense the sand around a pattern 18 in. high by 24 in. diameter is stated to be 1½ minutes, and moulds can be formed from patterns 1 in. to 20 in. high. Moulding boxes with or without bars can be used. The moulding boxes are lifted clear of the patterns by means of lifting cylinders, no racks or pinions being employed. The sand is formed hardest about the pattern, therefore no venting is required. By the use of the turnover device a large number of regular wood patterns can be used without the use of stripping plates.

Some founders have contended that moulding machines are only profitable so far as repetition work is concerned, but this machine, it is claimed, will not only expeditiously turn out repetition work, but also a very large variety of general jobbing work at a speed that could not possibly be attained by other means. The machine is said to accommodate itself to nearly every variety of pattern sent to a foundry.

For this machine is claimed strict uniformity of moulds and the least consumption of power. It is necessary neither to tuck the sand around the pattern at the joint, nor ram it on the top. The facing sand, whether it is the ordinary facing sand used in grey iron foundry work, or "compo" used in steel foundry work, is simply placed around the pattern, and the proper quantity of black sand filled in to form the mould. The combinations of the machine are then put into action and from that instant until the perfect formation of the mould and the release of the pattern, no hand work is required, not even when the mould is on the floor.

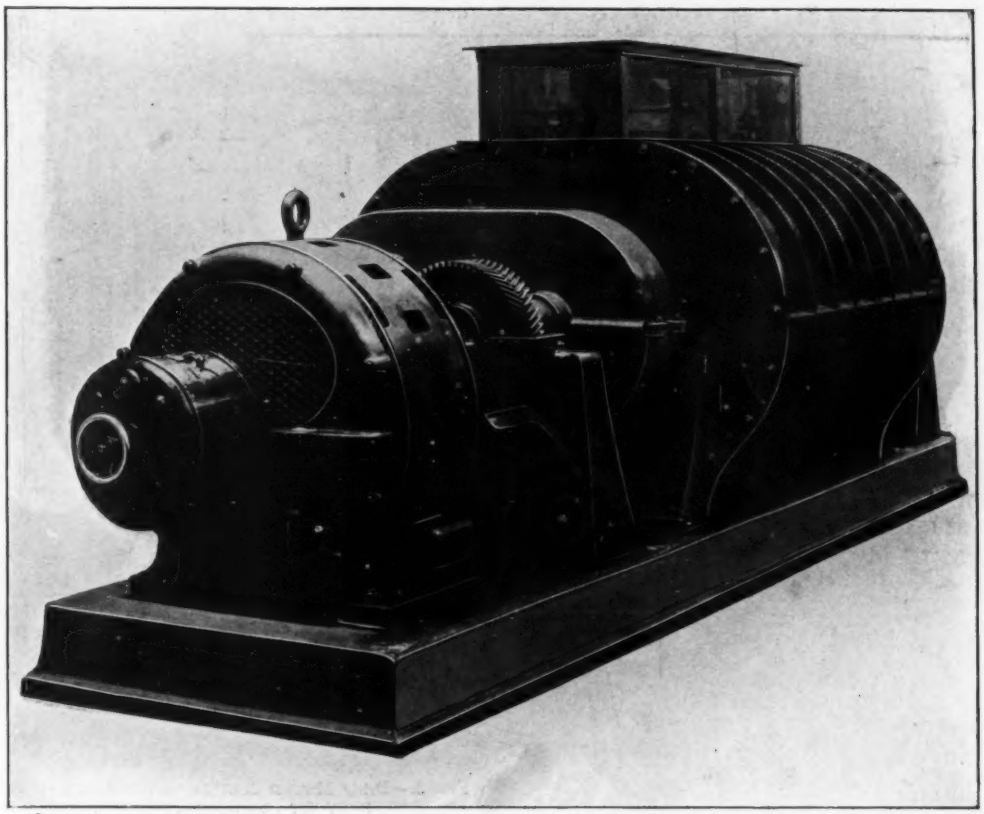


FIG. 2.—ELECTRICALLY-DRIVEN "CLIMAX" BLOWER AND MOTOR COMBINED.

Moulds can be made by the machine with or without a stripping plate, and when a stripping plate is not used, it is not necessary to use a turnover arrangement to draw the patterns. Either shallow or deep moulds can be made without a stripping plate or turnover arrangement, and the pattern can be dropped from the mould and leave the mould in the flask, not on the pattern plate. This can be done with moulds up to 20 in. square and 4 in. deep, and without any hand labour.

There are several automatic mechanisms on these machines which dispense with hand operations, but are of the most simple construction. All complications have been strictly avoided, so that it is impossible for

the inexperienced operator to make a mistake in the controlling and operating of the machine. The mould-forming mechanism is adjustable to suit various classes of work.

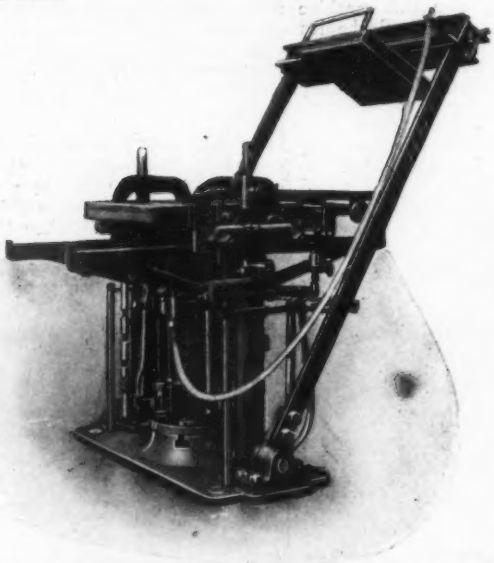


FIG. 1.—"AJAX" MACHINE WITH PRESSER HEAD THROWN BACK READY FOR RECEIVING PATTERN.

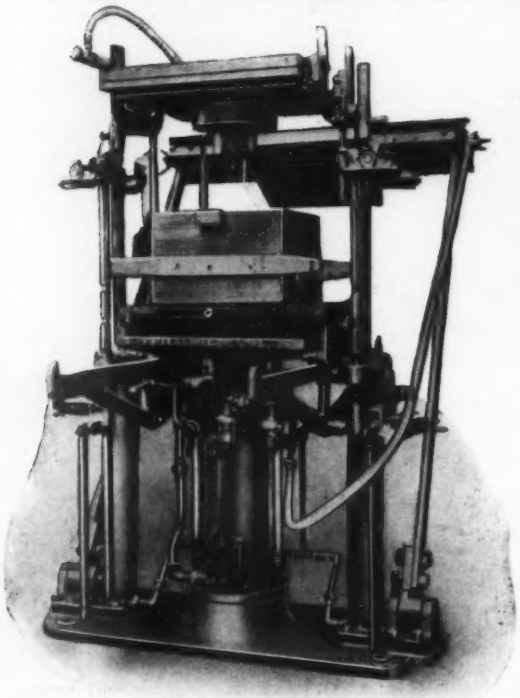


FIG. 2.—SHALLOW PATTERN MOULD COMPLETELY FORMED, TURNED OVER, AND BOX DROPPED CLEAR OF PATTERN.

A turnover arrangement can be supplied when required, but this turnover arrangement is more or less independent of the other mechanism, and can be swivelled away from the mould, thus making it very convenient for getting away the boxes. In conjunction with the turnover arrangement, a special self-levelling board is used, which takes care of any irregularities on the under side of moulding boxes, and thus the first adjustment of the machine serves for all boxes, irrespective of their frequent irregularity on the under side.

All round or square cores from 2 in. square or diameter up to 12 in. square or diameter can be expeditiously dealt with. The cores can be formed with any kind of a core iron in them, or without core irons or rods.

In the accompanying illustrations Fig. 1 shows the machine with the presser head thrown back, ready to receive the pattern. The machine with a shallow pattern completely formed, turned over, and the box dropped clear of the pattern is depicted in Fig. 2,

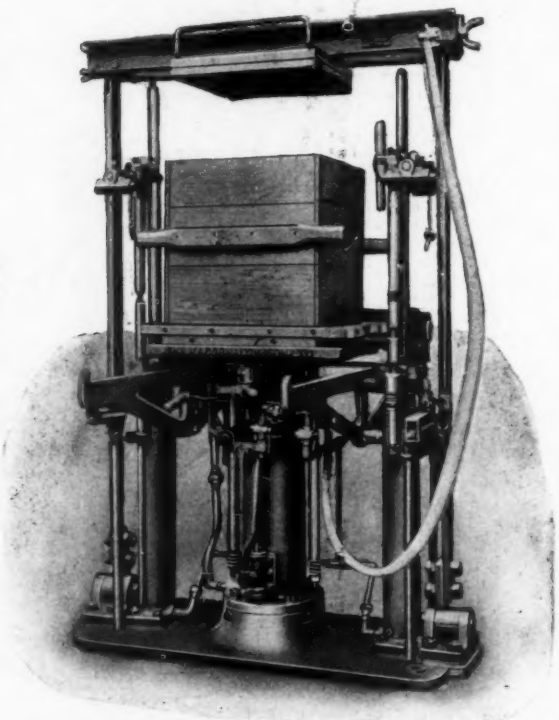


FIG. 3.—DEEP MOULD JOLTED AND PRESSER HEAD BROUGHT OVER FOR PRESSING.

while in Fig. 3 is shown a deep mould on the machine, the mould jolted and the presser head brought over for pressing. Fig. 4 depicts the machine with a deep mould, the box lifted clear of the pattern.

The makers of this machine are Messrs. John Macdonald & Son, Limited, Watt Street, Maryhill, Glasgow.

PHILLIPS' MONTHLY MACHINERY REGISTER. Published by Chas. D. Phillips, Newport, Mon.

We have received a copy of this Register with "Electrical Machinery, Motor-car and Steam Wagon Supplement." This publication, which we find has been in existence for thirty-seven years, is, we believe, an excellent medium for the sale and purchase of new and secondhand machinery of every description, as its circulation extends all over the world.

Queries and Replies.

Plaster of Paris.

In reply to the query by "Reader" as to the way to mix plaster of Paris, I use about 1 cwt. per month, and find, by experience, that the following is to be relied upon. Never buy a large stock, as it spoils by keeping. Have the plaster bin metal-lined, and in a warm place where a damp air cannot get at it. Before commencing to mix, stir up as much plaster as will be required, taking care to see there are no lumps in it. Dry plaster has a tendency to settle in keeping, and the stirring will remove this. Always have pure water, never have any acid or soap in it. Shake the plaster into the water rapidly and loosely. Do not stir the water during the mixing, but keep on putting plaster in till the water

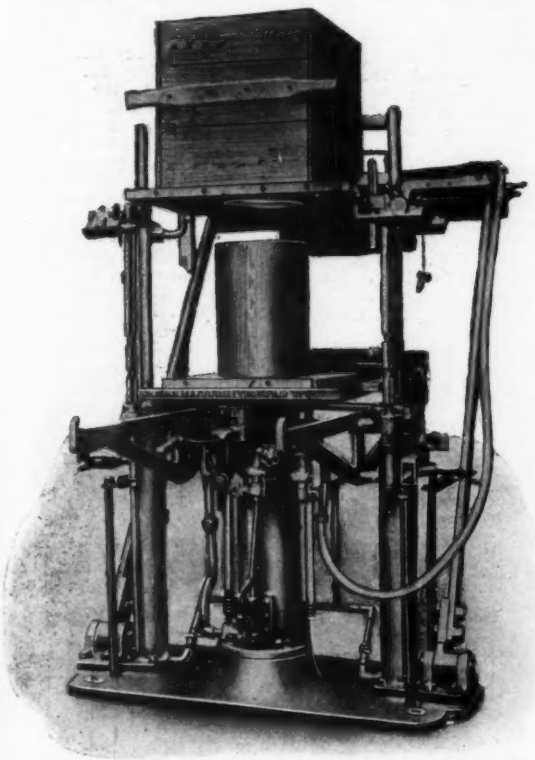


FIG. 4.—DEEP MOULD, BOX LIFTED CLEAR OF PATTERN.

is full of plaster and no free water remains. Do not stir while there is any dry plaster visible on top of water or there will be lumps. If any plaster remains dry on top put in more water, then stir and pour into mould. It should be like cream, and poured in a few minutes from first putting into the water, and should set hard within half an-hour. Put in a warm place to dry, not above blood heat (98 degrees).

"J. W. S."

Cast-Iron Rolls for Paper-Making Machinery.

From time to time we make cast-iron rolls from 4 to 5 tons in weight. The walls of the rolls are from 2 in. to 3 in. thick, and the rolls are about 14 ft. long and from 18 in. to 26 in. diameter. They are used in connection with paper-making machinery. We shall be obliged if you can give us any information as to a mixture for such rolls, that would resist or stand the mechanical action of the paper, which is mostly acids, alum, and sulphite pulp. The greatest difficulty we experience is getting the surface of the rolls, when finished, free from blemish outside. We enclose you a sample piece of iron, which has been broken off a roll we have just cast, but which is far too soft.

"C. W. C."

Reply.

The sample of iron is clearly unsuitable for hard grain rolls of any kind, and especially for rolls subjected to acid reactions. Apart from the looseness of the molecular structure, which itself might easily be avoided in the section mentioned, the sample shows a flat, weak crystal, and the mixture used appears to be much too high in carbon and silicon for work of this kind. The chief physical requirement in the casting is that it should be very dense (*i.e.*, the iron should be of the highest obtainable specific weight), and the chief chemical requirement that the sulphur be not too high, and the graphitic carbon as low as possible, compatible with a grey or faintly mottled iron. It would be advisable to get the necessary hardness and control the free carbon by using a fairly high manganese mixture, since this element is unaffected by acids. Silicon is not affected by acids, but it will be impossible to get a dense casting in this section with silicon much above 1.25 per cent. in the mixture. Further, the heat and fluidity of the mixture, a most important point, will have to depend mostly upon the manganese, since phosphorus must not go too high, as it is affected by acids.

The best way to arrive at the metal required is to take for a base a good percentage of one really low carbon iron, holding a low silicon, but running very fluid by good percentages of manganese and phosphorus; then add some high-grade grey coke pig, with minimum phosphorus and a low silicon, but with good manganese. As both the above will carry fairly high sulphur, some pure charcoal iron should be added, almost free from sulphur. As much hard, grey machine scrap may be included as the figures estimated for carbon and sulphur will allow (say, final total carbon in the mixture 3.4 per cent., sulphur 0.08 per cent.). There is no way out of using the charcoal iron (which will be expensive) as there is no other means of controlling sulphur except with high silicon pig, which is quite inadmissible.

The following are very suitable irons, according to the above specification, and we give the full mixture, showing the analysis of each iron and the final analysis of the mixture:—

	Total carbon.		Silicon.		Sulphur.		Phosphorus.		Manganese.	
	In pig.	In mixture.	In pig.	In mixture.	In pig.	In Mixture.	In pig.	In Mixture.	In pig.	In Mixture.
%										
40 Frodair...	3.1	1.24	1.20	0.48	0.07	0.028	1.1	0.44	1.3	0.52
20 Tebruk (charcoal)	3.4	0.68	0.70	0.14	trace	—	0.20	0.04	0.5	0.10
20 Norrfield strong	3.8	0.76	1.25	0.25	0.11	0.022	0.01	0.008	1.3	0.26
20 Hard grey scrap	3.8	0.76	1.50	0.30	0.10	0.02	0.65	0.13	0.7	0.14
Analysis of mixture		3.44		1.17		0.07		0.618		1.02

These ingredients will all have about the same melting point and specific density, and hence should mix thoroughly, and a great point is that the mixture should be melted hot and quickly, and cast as hot as ever possible. In connection with this, we might say that we judge, from examination of the piece of iron submitted, that high and low silicon irons have been

mixed, and possibly white and grey pigs, as there is clearly a very indifferent incorporation of the hard and soft portions of the charge. This defect should be avoided at any cost. Unless irons reasonably alike in their silicon content are taken all through the mixture, it will be difficult to get a thorough mixture of the different irons at the temperature at which the metal from which the sample comes (judging by its structure) was delivered from the cupola. The brands of iron named above are obtainable from us, and the analyses given are taken from the "Handbook for Ironfounders," issued by us, and recently reviewed in the FOUNDRY TRADE JOURNAL.

Yours, &c.,

THE FRODAIR IRON & STEEL COMPANY, LIMITED,
Fenchurch House, E.C.

Inventions.

Applications for Patents

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

29,044.*Machines for grinding rollers. Hoffmann Manufacturing Company, Limited, and O. A. Schmidt.
29,418.*Formation of flanges on cast metal valve boxes, pipes, etc. S. E. Alley, 121, West George Street, Glasgow.
29,469. Alloys. J. F. Duke.
29,710.*Manufacture of iron, steel, etc. M. J. Davidson.
29,715.*Revolving electrical furnaces. O. Serpek, 60, Queen Victoria Street, London.
29,830.*Manufacture of iron and steel. A. Boucher.
29,904.*Process for the manufacture of alloys. L. Weiss, 37, Essex Street, Strand, London.
30,182.*Process and apparatus for the manufacture of hollow metal bodies. W. Rating.
30,198. Treatment of melted metals, alloys, and steels. L. Baraduc-Muller.
30,295.*Gas-heated smelting or heating furnaces. Dellwik-Fleischer Wassergas G.m.b.H.
30,390.*Electric furnaces. V. Popp.

1911.

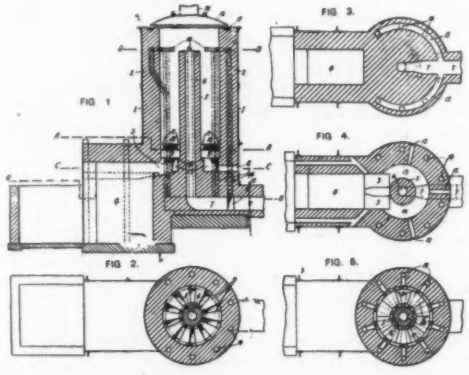
25. Casting steel. V. Stobie.
48. Metallic alloys. T. Wemyss-Just.
138. Metallic alloy. J. F. Duke.
672, 673, & 674.*Electric metallurgical furnaces. V. Stobie.
856.*Combined safety-guards and springs for moulding-machines. F. Penn and C. Farrell.
889.*Apparatus for machining pipe ends to form spigot and socket joints. Metal Jointing Company, Limited, and T. Harden.

Abstracts of British Patent Specifications recently accepted.

15,984 (1910.) *Hardening of Iron and Steel.* G. Daebritz, Niederwalluf, near Wiesbaden, Germany.—The iron or steel articles are first provided with a coat of varnish on those places which are to be hardened, and the articles thus partly varnished, are provided by the electrolytic process with a metal coating of copper, nickel or brass. The coating can, however, settle only on those places which are not varnished. The articles are then placed in a suitable cementing vessel, surrounded with hardening power, and then introduced into the furnace in which they are exposed to a temperature of about 900 degrees Centigrade for a longer or shorter time, according to the size of the article and to the depth of hardening. In that process only those places will be hardened which were protected by the layer of varnish from the settling of copper, whilst on the contrary, the metal coating deposited on the other places, prevents the gases of the hardening powder from exercising any action on the places which are to remain soft.

30,428 (1909). *Alloys suitable for Obtaining Chilled Castings.* R. C. Totten, 4,232, Fifth Avenue, Pittsburg, Pa., U.S.A.—The inventor uses iron smelted by the use of coke or coal, and which contains a large proportion of graphitic carbon, and only a very small proportion, sometimes only a trace, of combined carbon. He also employs ferro-chrome, usually containing a large proportion of combined carbon, ranging as high as 10 to 12 per cent., and nickel in suitable proportion, it being preferred that the chromium present shall be about 0.30 per cent. and the nickel about 0.70 per cent. of the mixture. However, the proportion of nickel may vary from 0.35 to 0.70 per cent., and the chromium from 0.15 to 0.30 per cent., according to the desired result. He also uses a chilling cast iron either in pig metal form or in the form of old car wheels, and where the same is employed the proportion of nickel employed varies according to the depth of chill to be produced and the proportion of old car wheels in the casting metal and the increased strength to be given to the casting, as the nickel increases the tensile strength of the metal and also acts to decrease the depth of chill. The ferro-chrome provides a large proportion of combined carbon, and in proportion as it is employed a greater quantity of ordinary iron may be employed, the ferro-chrome furnishing the combined carbon to give chilling qualities to the metal. For some purposes such as the manufacture of car wheels or chilled rolls steel is employed to add to the strength of the casting metal, the proportion of steel being 5 per cent. to 30 per cent., depending upon the amount of chill required in the car wheel or chilled roll, and increasing in proportion to the increase of nickel.

30,076. (1909). *Annealing Furnaces.*—R. F. Hislop and G. R. Hislop, Jnr., Underwood House, Paisley. Figure 1 is a longitudinal vertical section of the furnace; Figures 2, 3, 4, and 5 are sections on the lines A—A, B—B, C—C, and D—D, respectively, of Figure 1. The



Annealing Furnaces, by Hislop.

annealing furnace 1, which is built vertically and in cylindrical form, is formed by walls 2 of firebrick, suitably bound together by plates on the outside. At the lower end of the furnace openings 3 are formed for admission of gases. In the centre of the furnace a column 5 is constructed, so as to reduce the area of the annealing chamber and to conserve the heat, and is formed with a central flue 6 connected with a flue 7 leading to the chimney. From the chamber 13 the gases are distributed to the furnace. Outlets 14 for the waste gases are formed in the wall of the furnace preferably near the top. The top of the furnace is covered with a portable plate 16 of suitable shape and dimensions, and made preferably with the edges turned down so as to engage with a trough 17 formed on the top of the furnace walls. The trough when filled with sand forms an effective seal. The waste gas outlets 14 and the flue 6 may be closed, or the central column may be made solid and take the gases off through a chimney 18 attached to the top plate 16, as indicated by dotted lines in Figure 1.

Trade Talk.

THE CARBON TOOL COMPANY have removed to Albany Road, Coventry.

MESSRS. PORTER & COMPANY, have removed to the City Iron and Steel Works, Broadgate, Lincoln.

THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, of Rugby, have opened a branch office at Castle Buildings, Swansea.

THE foundry of Messrs. F. Manby & Brothers, Skipton, has been acquired by Messrs. Marsden & Naylor, Firth Street, Skipton.

THE London Smelting Works in Westferry Road, Millwall, were found to be on fire on January 16, the offices being considerably damaged.

A FIRE broke out at the brassfoundry and warehouse in Birmingham, of Samuel Heath & Sons, Limited, recently, doing considerable damage.

MR. R. C. V. WHITFIELD has established himself in business at 18, Albert Road, Middlesbrough, as a consulting metallurgist and engineer.

ENGINEERING UNDERTAKINGS, LIMITED, is being wound up voluntarily, with Mr. T. E. Kay, 19, Johnson Street, Cheetham, Manchester, as liquidator.

JAMES WILLIAMS & COMPANY, LIMITED, has been registered with a capital of £12,000 in £1 shares, to carry on the business of engineers, etc.

THE London offices of Spear & Jackson, Limited, Sheffield, have been removed to 32, Mansion House Chambers, 11, Queen Victoria Street, E.C.

MESSRS. SMITH & SON, brassfounders, metal rollers, etc., 44, Princip Street, Birmingham, have removed to the Waterloo Works, Aston Road, Birmingham.

THE ADDERLEY BRASSFOUNDRY COMPANY, LIMITED, is being wound-up voluntarily, with Mr. F. M. Hawnt, of 110, Colmore Row, Birmingham, as liquidator.

THE rumour that the business of the Diesel Engine Company, Limited, is about to be taken over by Vickers, Sons & Maxim, Limited, has been officially denied.

THE PATENT WOOD PIPE & TUBE COMPANY, LIMITED, is being wound up voluntarily, with Mr. J. G. Nixon, 18, Dean Street, Newcastle-upon-Tyne, as liquidator.

MESSRS. ANDRE CITROEN & COMPANY, makers of the Citroën machine-cut helical gears, have removed to larger premises at 27, Queen Victoria Street, London, E.C.

FRANK WIGGLESWORTH & COMPANY, LIMITED, Clutch Works, Bradford, have appointed Messrs. Irwin & Jones, 5, London Wall Buildings, E.C., as their London agents.

THE JUDSON-JACKSON COMPANY, 14, Great Smith Street, Westminster, S.W., have been appointed sole British and Colonial agents for Schaerer & Company, Karlsruhe.

THE capital of the Lambeth Brass and Iron Company, Limited, has been reduced to £16,000, divided into 1,000 preference shares of £10 each, 3,000 ordinary shares of £2 each.

AT the annual dinner of the Manchester and District Ironfounders Employers' Association, recently, the retiring President, Mr. George Leek, of the Hope Foundry, Salford, was re-elected.

THE firm of Neale & Scott, carrying on business as engineers at 2, Burrell's Lane, Glasgow, has been dissolved by the retirement of Mr. T. S. Neale Mr. A. Scott will continue the business.

MR. J. BEAUMONT PERCIVAL, registered patent agent, late of E. R. Royston & Company, has opened offices at 61, Lord Street, Liverpool, to carry on business as a patent agent and consulting engineer.

LANCASTER & TONGE, LIMITED, engineers, iron and brass founders, of the Lancaster Works, Pendleton, Manchester, have appointed Mr. W. E. Bullick, 137, Royal Avenue, Belfast, as their Belfast and district agent.

THE firm of Buchan & Duncan, engineers, Methil, of which Mr. J. S. Buchan and Mr. W. Duncan were the sole partners, has been dissolved. Mr. J. S. Buchan will in future carry on the business under the style of Buchan & Duncan.

IN the Winding-up Court, on January 17, Mr. Justice Swinfen Eady had before him the petition of Gill & Reigate, Limited, and another, for the compulsory winding up of Cone Jackson Engineering Company, Limited. His Lordship made a compulsory order.

THE Council of the Iron and Steel Institute will shortly proceed to award the Andrew Carnegie Research Scholarships for 1911 Intending candidates should communicate before February 28 with Mr. G. C. Lloyd, secretary, 28, Victoria Street, London, S.W.

MR. A. H. STEPHENS and Mr. W. G. Smith, for many years with James T. Donald & Company, Limited, McAlpine Street, Glasgow, have begun business as machinery merchants and agents under the style of Stephens & Smith, at 355, Argyle Street, Glasgow.

MESSRS. D. & A. HOME-MORTON, consulting engineers and industrial works designers, of Glasgow and Birmingham, have removed their Birmingham office, which is under the control of Mr. Andrew Home-Morton, to Norwich Union Chambers, Congreve Street, Birmingham.

MR. T. H. ROBERTS-WRAY, who has been with Messrs. Crompton & Company as chief representative for eight or nine years, has now severed his connection with that company, and has started on his own account as a consulting and inspecting engineer at 15, Leadenhall Street, E.C.

MR. AUGUST REICHWALD, of Finsbury Pavement House, London, E.C., announces that the business which in recent years has been carried on by him in partnership with his two sons, E. E. and V. B. Reichwald, has been transferred to August Reichwald, Limited, which has been registered as a company for this purpose.

MR. WILLIAM CRESSWELL GRAY, J.P., has tendered his resignation as a director of the South Durham Steel and Iron Company, Limited, and Mr. G. Mure Ritchie, chairman of the Millom and Askam Hematite Iron Company, Limited, has been elected to succeed him. Mr. J. E. Rogerson, chairman of John Rogerson & Company, Limited, has also been added to the board.

MR. H. R. PHILIP, who has been appointed, in conjunction with Mr. J. Watson, to the control of the steel foundry department of the works of Cammell, Laird & Company, Limited, Sheffield, has been in the service of the Steel Company of Scotland, Limited, for some 30 years, latterly as joint manager at the company's Hallside Works, along with Mr. Watson.

THE co-partnership of Smillie & Robertson, coppersmiths and brassfounders, 71, Lancefield Street, Glasgow, and Abercorn Road, Belfast, has been dissolved by the retiral of Mr. T. Macqueen Robertson. Mr. Samuel Smillie has now assumed as a partner Mr. William F. S. Taylor, and the business both in Glasgow and Belfast will be carried on under the style of Smillie & Company.

THE BRIGHTSIDE FOUNDRY AND ENGINEERING COMPANY, LIMITED, of Sheffield, have just secured the order for the turbine drum casings and some heavy accessory iron castings for the Dreadnought which Cammell, Laird & Company, Limited, are building. The casings for the two drums will consist of four iron castings of large dimensions, weighing close upon 50 tons each.

THE shareholders of the Tyneside Engine Works (Cardiff), Limited, have decided to voluntarily wind-up the concern. Mr. W. P. Annear, 156, Cathedral Road, Cardiff, has been appointed liquidator for the purpose of such winding-up, with power to carry out the sale of the business, with an agreement between the company and the Tyneside Engine Works (1910), Limited.

THE HON. MARMADUKE FURNESS, and Mr. T. Richardson have resigned their seats on the board of Richardsons, Westgarth & Company, Limited, and the vacancies have been filled by the appointment of Mr. J. Esplen, of Messrs. Wm. Esplen & Sons, consulting engineers, Liverpool and London, and Admiral Sir Archibald L. Douglas, a director of Hadfield's Steel Foundry Company, Limited, Sheffield.

SIR FREDERICK HOWARD, and Messrs. James H. Howard, John H. Howard, and G. Howard, carrying on business as agricultural engineers and implement makers, at the Britannia Iron Works, Bedford, under the style of James and Fredk. Howard, have dissolved partnership. The business will be carried on in future by Messrs. James H. Howard, John H. Howard, and G. Howard under the same style.

DAVID BROWN & SONS (HFD.), LIMITED, have recently installed at their Park Gear Works, Huddersfield, a special plant for cutting double helical wheels direct from the solid with continuous teeth. By this method of cutting the centre or "V" portion is retained, thus adding greatly to the strength and efficiency of the gear. The company have, furthermore, secured the sole rights for the construction of these machines.

ARRANGEMENTS have been made between the J. W. Paxson Company, Philadelphia, Pa., U.S.A., and Mr. A. E. Outerbridge, junr., foundry chemist and metallurgist, of Wm. Sellers & Company, Inc., Philadelphia, for the sale of Outerbridge silicon alloy, as covered by patents owned by him. This alloy is claimed to make grey iron castings softer, stronger, cleaner and more homogeneous, and to reduce shrinkage, cracking and blowholes and increase ductility.

THE new air-desiccating plant recently completed at the blast furnace plant of the Brymbo Steel Company, Limited, North Wales, is, we are informed, working most satisfactorily. The special feature of this plant, which was supplied by Ransomes & Rapier, Limited, of London and Ipswich, is that it is worked almost entirely from the exhaust steam of the blowing engine, which exhausts into the ammonia absorption refrigerating machine at a pressure of 1 lb. per square inch.

AT a meeting of the shareholders of Bever, Dorling & Company, Limited, held at the Bowling Iron Works, Bradford, Yorks., resolutions were passed to the effect that it was desirable to reconstruct the company, and accordingly that the company be wound-up voluntarily, and that Mr. R. L. Bullock, 1, St. Michael's Terrace, Headingley, be appointed liquidator. The liquidator was authorised to consent to the registration of a new company, to be named Bever, Dorling & Company, Limited.

THE Engineering Trade Advisory Committee of the Leeds Technical School, comprising representatives of employers and trade associations, has for some months been considering the question of providing evening instruction for moulders and others engaged in ironfounding. To ascertain the feeling of the trade, a public lecture on "The Romance of Cast Iron," addressed to foundrymen, was given by Mr. Robert Buchanan, on January 18, at the Central Technical School. Mr. E. E. Lawson, of the Hope Foundry, presided.

THE Status Prize may be awarded by the Council of the Society of Engineers (Incorporated) each year for the next three years ending 1913 for the best paper written by any person on the subject of "How to Improve the Status of Engineers and Engineering, with Special Reference to Consulting Engineers." In 1911 the prize will consist of books and/or instruments selected by the author of the premiated essay, to the value of six guineas. The essay, which is to contain not fewer than 4,000 nor more than 6,000 words, must be received by the Secretary on or before May 31 next.

ONLY those intimately concerned are aware of the extent to which steel castings are being purchased from France and Belgium, at prices which cannot be approached by British producers. Our representative was recently shown a quotation sent to a large engineering firm in the North. The contract was for 50 tons, to be taken in lots of not less than 10 tons, the castings averaging ¼ cwt. upwards, and the price £16 per ton, less 5 per cent. for cash, delivered, whilst for an additional £2 per ton the castings are guaranteed to British Government test. Our representative was informed that Sheffield quotations to the same specification were £20 to £23.

AT a recent meeting of the shareholders of Thos. Perry & Son, Limited, held at 79, Darlington Street, Wolverhampton, the following resolution was duly passed and subsequently confirmed:—"That having regard to the agreement for sale of the 24th day of November, 1910, and the sale of the undertaking thereby agreed to be made, it is desirable to wind-up this company, and accordingly that this company be wound-up voluntarily; and Alfred Charles Lyon, of Albrighton Hall, in the county of Salop, managing director of the company, be and he is hereby appointed liquidator for the purpose of such winding-up." A meeting of the creditors will be held at the same address on February 7.

ON January 21 a meeting of the members of the South Staffordshire Iron and Steel Institute was held at the Institute, Dudley. Mr. Walter Macfarlane, who presided, said that, acting on the suggestion of Mr. Moses Millard, one of the oldest members of the Institute, the Council had had under consideration the idea of gathering into one paper reminiscences of some of the elder Staffordshire men dealing with the processes that were formerly practised in the county. The Council had already made some progress in the matter, having obtained very valuable information, and with the intimation of the next meeting there would be an invitation to members to help in making the record as complete as possible. Mr. O. F. Hudson, M.Sc., then read a paper on "The Condition of Carbon in Cast Iron."

WHEN completed the new foundry of Messrs. Whitley Partners, Railway Works, Leeds, will be the largest brass foundry in the Yorkshire district. The accommodating building was formerly a machine shop, the walls of which have been raised, and the internal equipment is now well advanced. This addition to the works was found necessary, not only to cope with the growing demand for the Whitley valves, but to enable the firm to deal expeditiously with what is now a very important branch of their business—spun brass shells for pump and cylinder linings, pump rods, propeller shaft bushes and coverings, etc. These shells are cast in revolving mills, without the use of a core, by means of which equal density is secured over the entire surface, thus giving a casting entirely free from blow-holes. Castings of this type are made up to two tons in weight, with a length of 15 ft., and diameter up to 28 in. The plant at present being put down is, however, designed for still larger sizes.

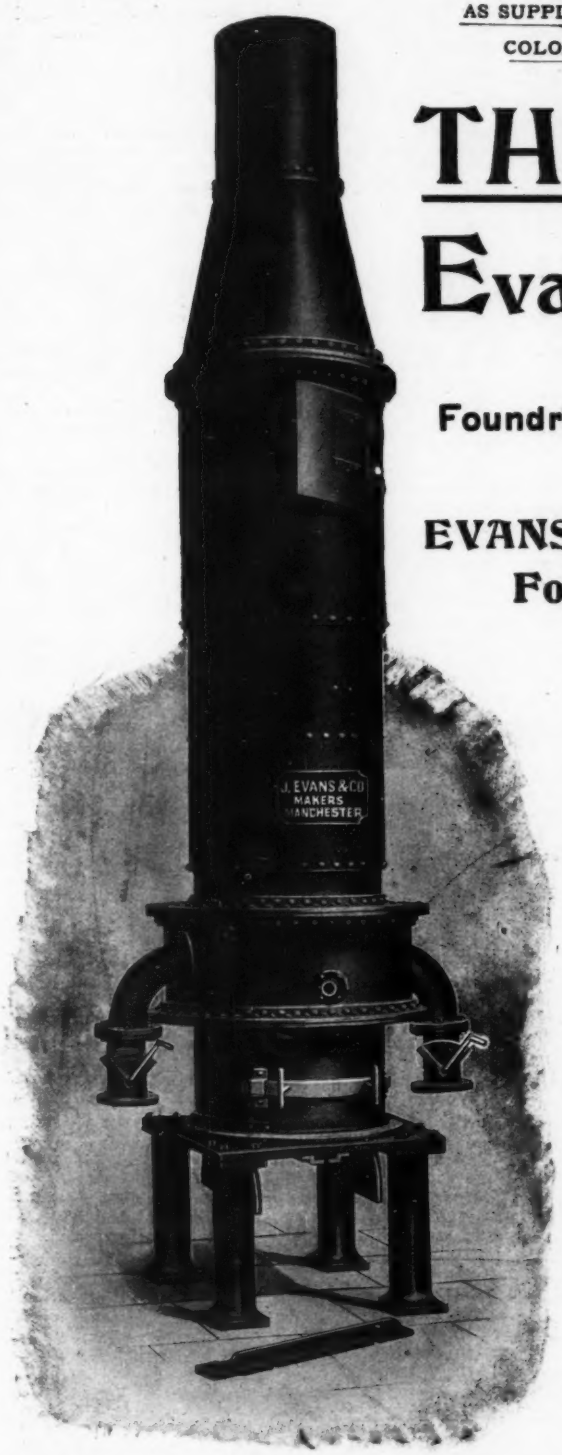
AT the twenty-first meeting of the Council of the International Association for Testing Materials, held recently at Brussels, Professor Howe moved, in connection with the question of the uniform nomenclature of iron and steel, that, on account of the importance of this question, some prominent societies should be invited to be officially represented on the Commission. The following societies were mentioned in this respect:—The Iron and Steel Institute, the American Society of Mechanical Engineers, the Verein deutscher Eisenhüttenleute (Union of German Ironmasters), the Jernkontor and the Comité des Forges de France. The resolution was agreed to. It was agreed to appoint a special sub-committee of Committee 1a for cast iron, in order to push on the work of the Committee. The revision of the list of problems then followed, in the course of which several alterations of the text were made. The following gentlemen were subsequently invited to report on the principal questions:—(a) Special steel: Professor L. Guillet (Paris); (b) metallography (slag enclosures, homogeneity, weldings): Professor E. Hevn (Gr.-Lichterfelde); (c) hardness testing and resistance to mechanical wear, Mr. E. H. Saniter (Sheffield); (d) impact tests: Mr. G. Charpy (Montlucon); (e) testing metals by alternating stresses: Professor H. Le Chatelier (Paris); (f) testing of cast-iron: M. A. Damour (Bayard, Haute Marne); (g) influence of increased temperature on the quality of metal: M. J. E. Howard (Watertown). The twenty-second meeting of the Council was fixed for Saturday, March 18, 1911, in Stuttgart.

AS SUPPLIED TO THE ADMIRALTY, WAR OFFICE,
COLONIES, AND FOREIGN GOVERNMENTS.

THE Cupola.
Evans's Rapid.

Foundries Completely Furnished.

EVANS'S NEW CUPOLETTE
For Emergency Work.



Telegrams: "LADLES, MANCHESTER."

James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Personal.

MR. EDWIN JAMES HUNT, a director of Chance & Hunt, Limited, has been elected an honorary member of the Staffordshire Iron and Steel Institute.

MR. G. A. BOEDDICKER has been elected to the board of Muntz's Metal Company, Limited, in the place of the late Mr. H. Graham Harris.

MR. GEORGE MACPHERSON, J.P., of Messrs. Philip Williams & Sons, Wednesbury Oak, Tipton, has been appointed Deputy-Lieutenant for Staffordshire.

THE gross value of the estate in the United Kingdom of the late Hon. Sir George Alexander Drummond, a director of the Mond Nickel Company, Limited, is £6,718.

THE late Mr. Richard Hill, chairman of R. Hill & Company, Limited, Middlesbrough, left estate valued at £77,695 18s. 9d. gross, of which £24,904 17s. 10d. is net personalty.

THE gross value of the estate of the late Mr. F. Stanton, of The Cottage, Baslow, Derbyshire, formerly in the service of Vickers, Sons & Maxim, Limited, Sheffield, is £10,181.

MR. R. R. BEVIS, managing director of Cammell, Laird & Company, Limited, has been elected chairman of the Advisory Committee to the Liverpool and Birkenhead district Labour Exchange.

MR. W. ROBINSON, formerly connected with William Jessop & Sons, Limited, Sheffield, has joined the firm of Messrs. H. & R. Waterfall & Barber, of the Prometheus Steel Works, Sheffield.

AT Newcastle-on-Tyne, on January 16, in the presence of a large and influential gathering of citizens, the Honorary Freedom of Newcastle was conferred on the Lord Mayor, Sir William Haswell Stephenson.

MR. JAMES A. FARRELL will be elected President of the United States Steel Corporation, in succession to Mr. Corey, resigned. Mr. Farrell is at present president of the Steel Products Company.

MR. T. OUTHWAITE, of Linthorpe, Middlesbrough, has retired from the staff of Bolckow, Vaughan & Company, Limited, after a continuous career of service extending over the long period of 56 years.

THE gross value of the estate of the late Mr. John Moncur, of Longcroft, Harrington, Cumberland, for many years secretary and manager of the Distington Ironworks, is £5,663, including net personalty of £4,162.

MR. G. K. WARD, Mr. M. E. Denny, and Mr. J. McAusland Denny, jun., have been assumed partners in the Dumbarton firms of Messrs. William Denny & Brothers, of the Leven Shipyards, and Messrs. Denny & Company.

MR. W. S. WILSON has resigned his position as outside manager of the electrical department of Clarke, Chapman & Company, Limited, to take up the position of branch manager for Johnson & Phillips, Limited, at 44B, Blackett Street, Newcastle-on-Tyne.

MR. W. G. SPENCE, who has been manager for 14½ years of the Neptune Engine Works of Swan, Hunter & Wigham Richardson, Limited, Walker, has been appointed a director and general manager of the engine works of George Clark, Limited, Sunderland.

MR. WM. CLARK, formerly general manager of the Steel Company of Scotland, Limited, who has been appointed to a similar position in the works of Vickers, Sons & Maxim, Limited, Sheffield, has been the recipient of further presentations from friends in the West of Scotland.

MR. JAMES FARR, who, on the 7th ult., completed 50 years' service with Messrs. Fairbairn, Lawson, Combe & Barber, Limited, the well-known Leeds engineering firm, and who now holds the position of manager of the moulding department, was recently the recipient of a presentation from the employés.

MR. A. H. COOPER, formerly of Middlesbrough, has been appointed managing director of the Partington Steel & Iron Company, Limited, of Cadishead, near Manchester, which is the official name of the new iron and steel works which the Pearson & Knowles Coal & Iron Company, Limited, are erecting at Cadishead, near Manchester.

SIR HUGH GILZEAN REID has been elected chairman of Richard Hill & Company, Middlesbrough, in succession to the late Mr. Richard Hill, founder, and for nearly forty years chairman of the concern. Sir Hugh Gilzean Reid has been a director of the Company for many years. Mr. Frederick Bowes, for a long period general manager, has been appointed to fill the vacancy on the board.

Deaths.

MR. JOSEPH PARKINSON, senior partner of Messrs. J. Parkinson & Son, machine tool makers, Shipley, died recently.

MR. W. L. HALLEY, of the Dennystown Brass Works, died recently at his residence, Oxhill, Dumbarton, at the age of 73 years.

MR. SAMUEL BUTLER, of Messrs. Samuel Butler & Company, Albion Engineering Works, Stanningley, died recently, aged 60 years.

THE death is reported of Mr. W. H. Rhodes, managing director of Joseph Rhodes & Sons, Limited, Grove Ironworks, Kirkgate, Wakefield.

MR. G. B. SMITH, of Messrs. William Smith, gas meter manufacturers, Kennington Park Road, London, S.E., died recently, aged 74 years.

MR. G. H. BROWN, head of Browns Foundry Company, Limited, Nelson Iron Works, Stockbrook Street, Derby, died recently, aged 68 years.

MR. J. W. BRAY, of the Hall, Scalby, Scarborough, and chairman of George Bray & Company, Limited, engineers, Leeds, died recently, aged 36 years.

MR. A. W. HOULSON, J.P., of Dowlais, at one time secretary of Guest, Keen & Nettlefolds, Limited, died, after a long and severe illness, on January 21, at his residence, Caeharris House, Dowlais.

MR. JOSEPH TRIPPETT, head of the firm of Messrs. Joseph Trippett & Sons, manufacturers of steel castings, Coleridge Road, Attercliffe, Sheffield, died, in his 71st year, at his home, 62, Earl Marshall Road, Pitsmoor, recently.

MR. C. H. MORGAN, president of the Morgan Construction Company and the Morgan Spring Company, and a well-known inventor of rolling mill and wire-drawing machinery, died at his home in Worcester, Mass., on January 10, aged 80 years.

M. KJELLIN, the well-known Swedish engineer, died on December 30 last, at the age of 38 years. The name of Kjellin is principally associated with the electrical induction-furnace, the deceased gentleman being the inventor of the "Kjellin furnace."

MR. SAMUEL POPE, of Holly House, Risca, formerly managing director of Messrs. White & Company, of the Foundry, Risca, died suddenly at his residence on January 25. The deceased gentleman, who came to the district about 10 years ago from Sheffield had been in failing health, but his death was not at all expected.

MR. JOHN BERRY, J.P., of Bolton, died on January 22, aged 72. The deceased gentleman was always considered to be the pioneer in England of technical education. He was apprenticed to the turning and fitting department of Messrs. Dobson & Barlow. He soon became foreman draughtsman, and remained in the service of the firm 45 years.

MR. ARCHIBALD MACKELLAR, of the Finnieston Engineering Works, Glasgow, died recently at Ayr, at the age of 50 years. Mr. Mackellar was engaged in engineering work in the city for a long time, and about nine or ten years ago he became sole owner of the Finnieston Works, which he purchased from Messrs. George Smith & Son.

SOUND

STRONG, CLOSE-GRAINED

CASTINGS

Obtained by using

"TITANIUM THERMIT"

TINS READY FOR USE. **ALL SIZES from 2 cwt. to 20 tons.**

Prices and Particulars from

THERMIT LIMITED,

Telegrams: "FULMEN, LONDON."
Telephone: 3749 Central.

Works: **210a, Bow Rd., E.**

27, Martins Lane,
Cannon Street, E.C.

ELDERS FOUNDRY COKE

AS SUPPLIED TO THE
BRITISH
ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

METALS.	End Jan., 1911.	End Jan., 1910.
Iron—Scotch pig warrants ton	*55/7½	*57/9
—Middlesbro' warrants .. ton	49/4	51/9
—W.C. M/nos Bessemer ... ton	68 6	67 0
—Stock, Scotch ... .. tons	1,000	1,000
Copper—Chili bars, GMB ton	£55 5 0	£60 5/0
—Stock, Europe and afloat tons	†83,238	†109,082
Tin—English ingots ... ton	£194 15 0	£147 0/0
—Straits ... ... ton	£194 10 0	£148 5/0
—Stock, London, Holland, U.S.A., and afloat ...tons	††17,910	††21,358
Lead—English pig ... ton	£13 5 0	£14 0.0
Spelter—Ord. Silesian ... ton	£23 7/6	£23 7 6
Quicksilver (75lb)... bottle	£8	£9 10 0
Antimony—Regulus ... ton	£28 0/0 £29 0/0	£29 10/0

* Settlement price. † January 14. †† December 31.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (p'ain)	6 10 0	to	6 15 0
Pipes, 1½ to 2½ in.	4 17 6	to	5 2 6
,, 3 to 4 in.	4 10 0	to	5 0 0
,, 5 to 8 in.	4 7 6	to	4 10 0
,, 10 to 16 in.	4 7 6	to	4 10 0
,, 18 to 24 in.	4 7 6	to	4 10 0
Chairs	3 12 6	to	3 15 0
Floor plates (open sand)	3 0 0	to	3 5 0

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows :— Heavy wrought (mixed) £2 10s. 0d.; light wrought, £1 7s. 6d.; heavy cast £2 7s. 6d.; all per ton, f.o.b., London. Copper (clean) £51 10s. 0d.; brass (clean), £39 0s. 0d.; lead (usual draft), £12 0s. 0d.; zinc, £18 15s. 0d.; all per ton delivered merchant's yard.

BRADLEY & TURTON, LIMITED.—Capital £15,000 in £1 shares, to acquire the Clensmore Foundry and Caldwell Foundry, at Kidderminster, Worcestershire, and to adopt an agreement with E. Bradley and R. L. Bradley.

J. & A. LAW, LIMITED.—Capital £30,000 in £1 shares, to acquire and carry on the business of ironfounders and engineers hitherto carried on by J. & A. Law. Registered office: 3, James Street, Port-Dundas, Glasgow.

JOHN LAW & COMPANY, LIMITED.—Capital £30,000 in £1 shares, to acquire and carry on the business of hollowware manufacturers and ironfounders heretofore carried on by John Law & Company. Registered office: 3, James' Street, Port-Dundas, Glasgow.

New Companies.

COOPER-STEWART ENGINEERING COMPANY, LIMITED.—Capital £5,000 in £10 shares.

BRITISH FIRE APPLIANCES COMPANY, LIMITED.—Capital £2,000 in £1 shares.

NORTH-EAST COAST ENGINEERING WORKS (HULL), LIMITED.—Capital £8,000 in £10 shares.

EMPIRE ALUMINIUM COMPANY, LIMITED.—Capital £75,000 in £1 shares (25,000 preferred ordinary, and 50,000 deferred ordinary).

CARBORUNDUM COMPANY, LIMITED.—Capital £10,000 in £1 shares, to carry on the business of manufacturers of abrasive grinding wheels, etc.

DAVID AULD & SONS, LIMITED.—Capital £26,000 in £1 shares, to carry on the business of ironfounders, etc. Registered office: Whitevale Foundry, Glasgow.

LAMBOURNE & COMPANY (MANCHESTER), LIMITED.—Capital £10,000 in £1 shares, to carry on the business of engineers, etc. Registered office: 4, Piccadilly, Manchester.

SAUNDERS & YATES, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of engineers, &c. Registered office: Sandy Works, East Cote Lane, Harrow, Middlesex.

MELVIN WILLIAMS & COMPANY, LIMITED.—Capital £10,000 in £1 shares, to carry on the business of engineers, ironfounders, etc., and to adopt two agreements with E. M. Williams.

COOPER-STEWART ENGINEERING COMPANY, LIMITED.—Capital £5,000 in £10 shares, to deal in the articles produced by the Stewart & Clark Manufacturing Company and the Chicago Flexible Shaft Company.

CROMIL ENGINEERING COMPANY, LIMITED.—Capital £20,000 in £1 shares, to carry on the business of engineers, engineering merchants, etc., and to adopt an agreement with E. J. Crosier for the acquisition of the business referred to therein.

LONDON STEEL AND OIL FURNACE COMPANY, LIMITED.—Capital £58,000 in £1 shares, to carry on the business of manufacturers of and dealers in machines and apparatus for manufacturing, distributing, increasing, and improving the illuminating or heating power of gas, etc.

SAMUEL CUTLER & SONS, LIMITED.—Capital £70,000 (40,000 5½ per cent. cumulative preference), to carry on the business of contractors, founders, mechanical and gas engineers, etc., and to acquire the business carried on at Providence Iron Works, Millwall, as Samuel Cutler & Sons. Registered office: Providence Iron Works, Millwall, E.

BEVER, DORLING & COMPANY, LIMITED.—Capital £8,572 15s. (15,575 10s. non-cumulative preference and 14,282 2s. 6d. ordinary), to take over the business of engineers, founders, and merchants, carried on by Bever, Dorling & Company, Limited, at Bradford, and to adopt an agreement with the old company and R. L. Bullock, the liquidator.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

Established 1863.

JAS. DURRANS & SONS,

PHŒNIX WORKS, PENISTONE, Near Sheffield.

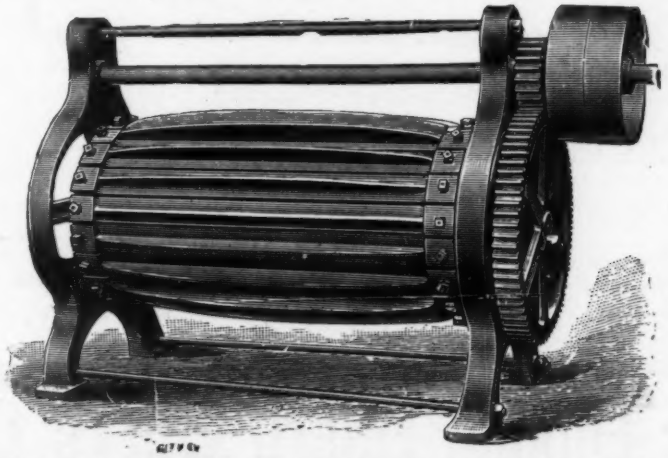
Manufacturers of all

FOUNDRY EQUIPMENTS,

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

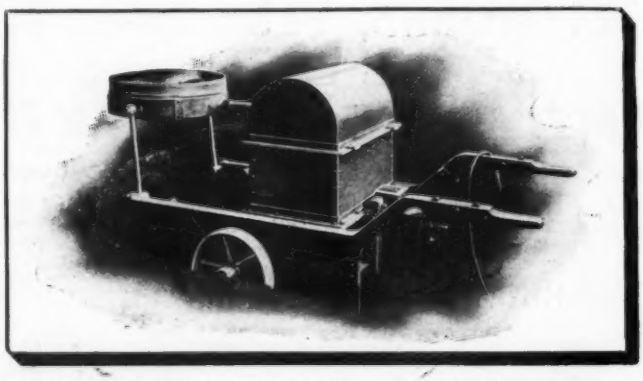
Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

Economy in Sand Riddling.

¶ Every foundryman knows the advantages of a thorough riddling of moulding and core sands preparatory to their use in moulding, and the riddle is one of the most frequently used appliances in the foundry. Poorly mixed and riddled sand means lost castings and increases the size of the scrap heap. On the other hand sand that has been well riddled will ram more uniformly, vent better and increase your percentage of clean, smooth castings.

¶ The "Lewco" Electro-Motor Sand Riddling Machine riddles the sand more effectively than it can be done by hand, reduces the liability of blow-holes and rough castings, because the sand is aerated, free from lumps and uniform. Mounted on a bogie, it can be wheeled down the tracks or carried by a crane to the spot where it is wanted and is then ready for work instantly; a length of cable from the nearest wall socket, the plug inserted and the machine is complete.

¶ The Motor and Starter are enclosed in a sheet steel casing, which thoroughly protects both from sand and dust. A standard 19 in. riddle is used and it can be changed in a few seconds.



¶ The machine will put through a half-inch riddle as much sand as two men can shovel into it, and with a $\frac{3}{16}$ in. riddle it will keep one man busy.

¶ Do you know how much it is costing you now to riddle your sand? With the Electro-Motor Sand Riddle the cost will be reduced to 4d. per ton when using a $\frac{3}{16}$ in. riddle and to about 3d. per ton when using half inch riddle. With these figures before you can you afford to wheel your sand to a stationary machine and wheel it back again or to continue riddling by hand?

Price Complete with ½ H.P. Protected Type Motor, length of cable and sample riddle - - - £28 0 0

Also Manufacturers of Sand Blasts, Moulding Machines, Emery Grinders, Abrasive Wheels, etc., etc.

The London Emery Works Co.,

Park Works,
Tottenham, London, N.

THE BUYER'S GUIDE

Addresses and further information will be found by reference to the Firm's Advertisement.

Abrasive Wheels.
Evans, J. & Co.
London Emery Works Co.
Jackman, J. W., & Co., Ltd.

Air Compressors.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Electrically Driven).
Jackman, J. W., & Co., Ltd.
Marshall & Co. Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Steam).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Belt).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Annealing.
Evans, J. & Co.
Phillips, J. W. & C. J.

Ash Crushing and Washing Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Barrels (Tumbling).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.
Tilghman's Patent Sand Blast Co., Ltd.

Barrows.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.

Bellows.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Durrans, Jas., & Sons.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Blacklead.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman J. W., & Co., Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Blowers.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Buffalo Forge Co., Ltd.
Davies, T., & Son.
Dempster, R. & J., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co., Ltd.
Phillips, J. W. & C. J.
Samuelson & Co., Ltd.
Thwaites Bros Ltd.
Ward, T. W., Ltd.

Buffing and Polishing Machines.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.

Casting Cleaners.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Pneumatic Engineering Appliances Co., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Cement.
Dyson, J. & J.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Lowood, J. Grayson, & Co., Ltd.
Marshall & Co., Horace P.
Olsen, Wm.
Plasti-Kion Co.
Silent Machine and Eng. Co.

Chaplets and Studs.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Motherwell, Wm., & Co.
Olsen, Wm.
Wilkinson, T., & Co., Ltd.

Charcoal.
Evans, J., & Co.
Firminger, J. & Co., Ltd.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
Sykes, James.
Walker, I. & I.

Charging Platforms.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Thwaites Bros., Ltd.

Coal Dust.
Cumming, Wm., & Co., Ltd.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Sykes, James.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.
Williams, John (Birmingham Sand) Ltd.

Coke (Foundry).
Elders Navigation Collieries.

Coke Breakers.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W., & C. J.

Core Boxes.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.

Core Compounds.
Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.
Wilkinson, Thos. & Co.

Core Gums.
Durrans, J. & Sons.
Evans, J., & Co.

Core Gums—*cont.*
Hall, Charles, & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd

Core Making Machines.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co
Marshall, H. P. & Co.
Phillips, J. W. & C. J.

Core Ovens.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J. & Co.
Hislop, R. & G.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.
Phillips, C. D.
Phillips, J. W. & C. J.

Core Ropes.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Wilkinson, T. & Co.

Core Vents.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Cranes.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J. & Co.
Jackman, J. W., & Co., Ltd.
Vaughan & Son. Ltd.
Ward, T. W., Ltd.

Crucibles.
Evans, J. & Co.
Hall, Charles, & Co.
Olsen, Wm.

Crucible Furnaces.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.

Crucible Furnaces (Lift-out)
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Phillips, J. W. & C. J.

Crucible Furnaces (Tilting)
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Crushing Mills.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.

Cupolas.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T. & Son.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.
Marshall, H. P. & Co.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

Cupola Linings.
Evans, J., & Co.
Hall, Charles & Co.
Harris & Pearson.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.

Emery Grinders.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davis, T., & Son.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.

Emery and Glass Cloth and Glass Paper.
London Emery Works Co.

Emery Wheels.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J. & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Mitchells Emery Wheel Co.

Facings.
Evans, J. & Co.
Olsen, William

Fans.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Buffalo Forge Co.
Davies, T. & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Jenkins, W. J. & Co., Ltd.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

Firebricks.
Durrans, J. & Sons.
Dyson, J. & J.
Evans, J. & Co.
Fyfe & Co., J. R.
Harris & Pearson.
Jackman, J. W., & Co., Ltd.
King Bros.
Lowood, J. Grayson, & Co., Ltd.
Pearson, E. J. & J.

Foundry Blacking.
Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J., & Co.
Firminger, J. & Co., Ltd.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Sykes, James.
Olsen, Wm.
Walker, I. & I.
Wilkinson, Thos. & Co., Ltd.
Williams, John (Birmingham Sand) Ltd.

Foundry Brushes.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, C., & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Phillips, J. W. & C. J.

Foundry Ladles.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T. & Son.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
McNeil, Chas.
Phillips, J. W. & C. J.
Thwaites Bros Ltd.

THE BUYER'S GUIDE.—*Continued.*

Foundry Rattlers or Fettling Drums.
Alldays & Onions
Davies, T., & Son
Durrans J., & Sons
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co.
London Emery Works Co.
Marshall & Co., Horace
Phillips, J. W. & C. J.

Foundry Sand.
Dyson, J. & J.
Evans, J., & Co.
Gould, Geo ge
Jackman, J. W., & Co., Ltd
Wilkinson & Co., Thos., Ltd.
Williams, J. (Birmingham Sand), Ltd.

Furnaces (Annealing).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J. & Co.
Hislop, R. & G.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Furnaces (Brass).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Furnaces (Melting).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Ground Gannister.
Durrans, J., & Sons.
Dyson, J. & J.
Evans, J., & Co.
Lowood, J. Grayson, & Co.
Walker, I. & I.

Grinding Machines and Tools.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.

Hammers (Steam).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Thwaites Bros., Ltd.

Hay Band Spinning Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.

Hoists.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J. & Co.
Jackman, J. W., & Co., Ltd.
Marshall, H. P., & Co., Ltd.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

Loam and Sand Mills.
Davies, T., & Son.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Ward, T. W., Ltd.

Melting Furnaces (Oil fired).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Mould Driers.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Moulding Machines.
Adaptable Moulding Machine Co., The
Britannia Foundry Co.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.
Pickles, James.
Pneumatic Engineering Appliances Co., Ltd.
Samuelson & Co., Ltd.
Whittaker, Wm., & Sons, Ltd.

Moulding Machines (Hand and Power).
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Pickles, James.

Pig Breakers.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Sonnenthal, Selig, & Co.

Pig-Iron.
Bradley & Sons, T. & I., Ltd.
Frodair Iron and Steel Co., Ltd., The
Goldendale Iron Co., Ltd.

Plumbago.
Bush, Henry C.
Cumming, Wm. & Co., Ltd.
Durrans, J., & Sons.

Plumbago—*cont.*
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Pneumatic Tools.
Jackman, J. W., & Co., Ltd.
J. Macdonald & Son, Ltd.
Marshall, H. P. & Co.
Pneumatic Engineering Appliances Co., Ltd.

Polishing Sundries.
Evans, J. & Co.
London Emery Works Co.

Publications.
Eagland & Co., Ltd.
Griffin, Charles & Co., Ltd.

Pyrometers.
Alldays & Onions
Phillips, J. W. & C. J.

Recording Gauges.
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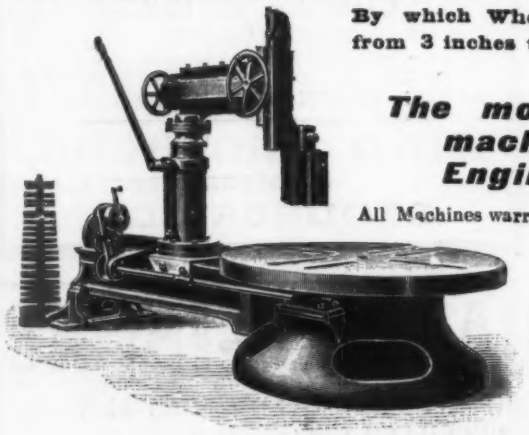

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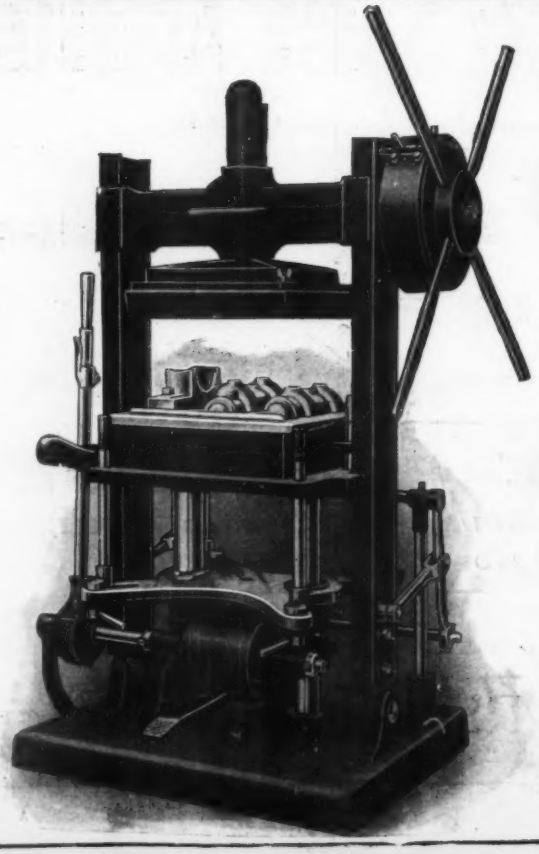

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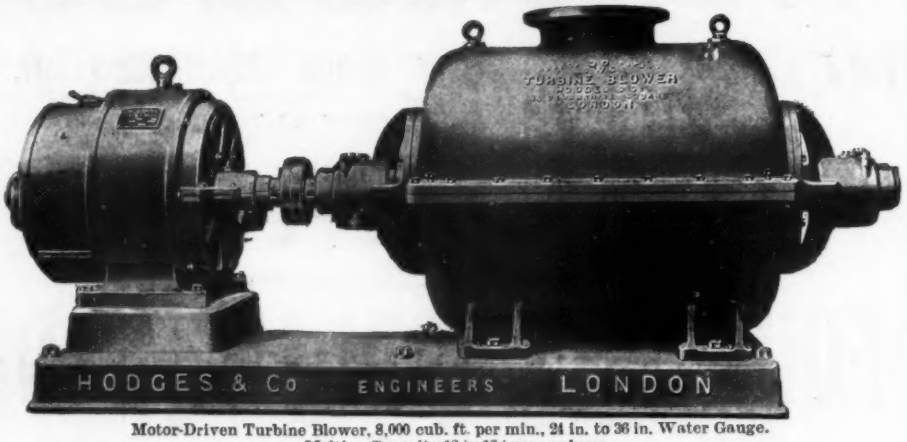

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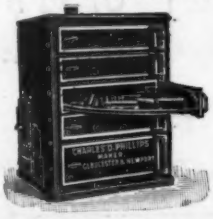

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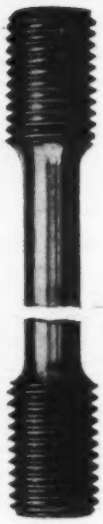

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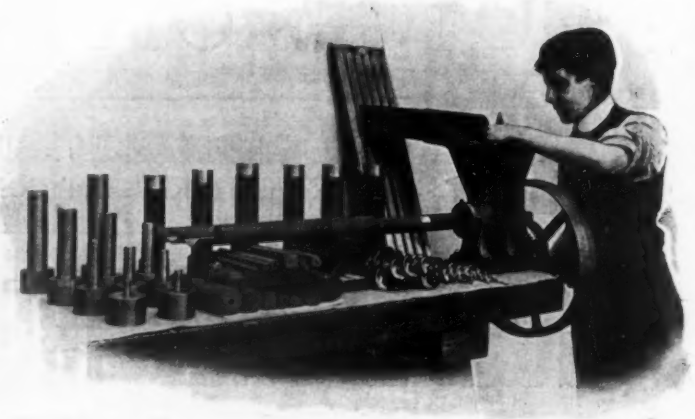

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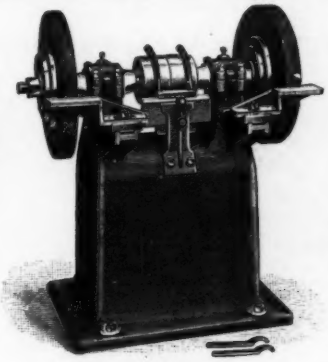

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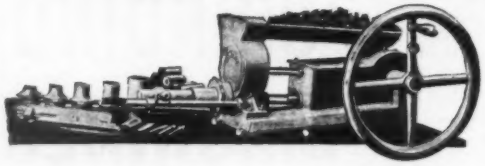

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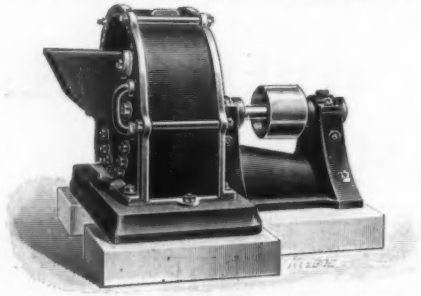

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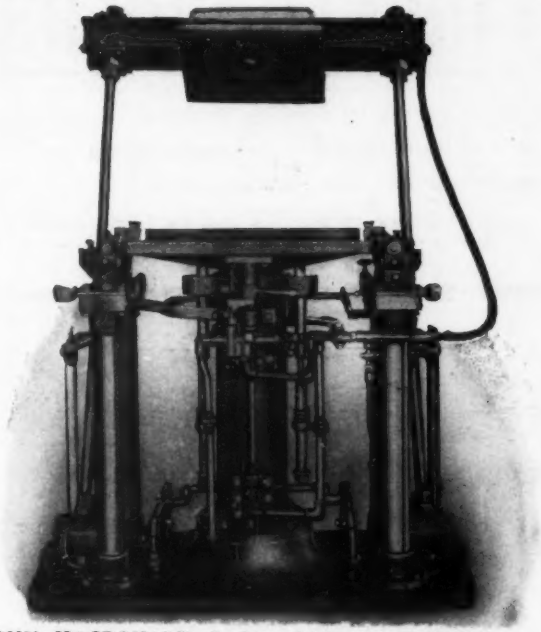

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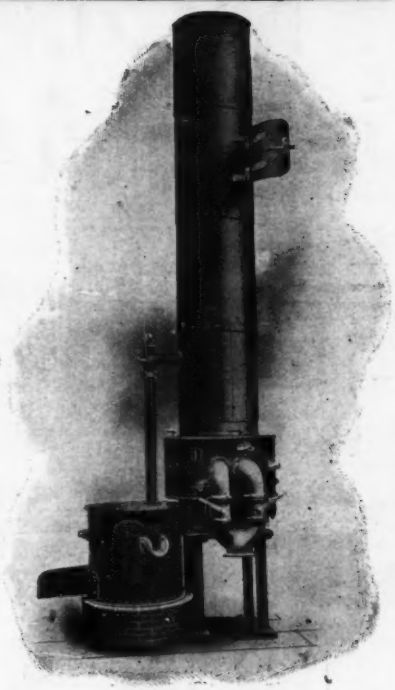

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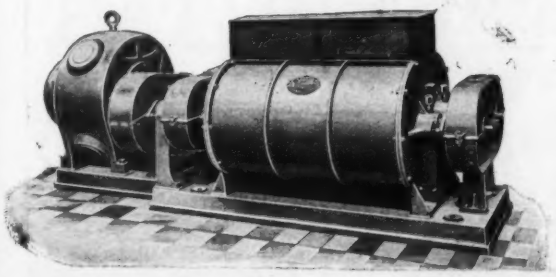

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